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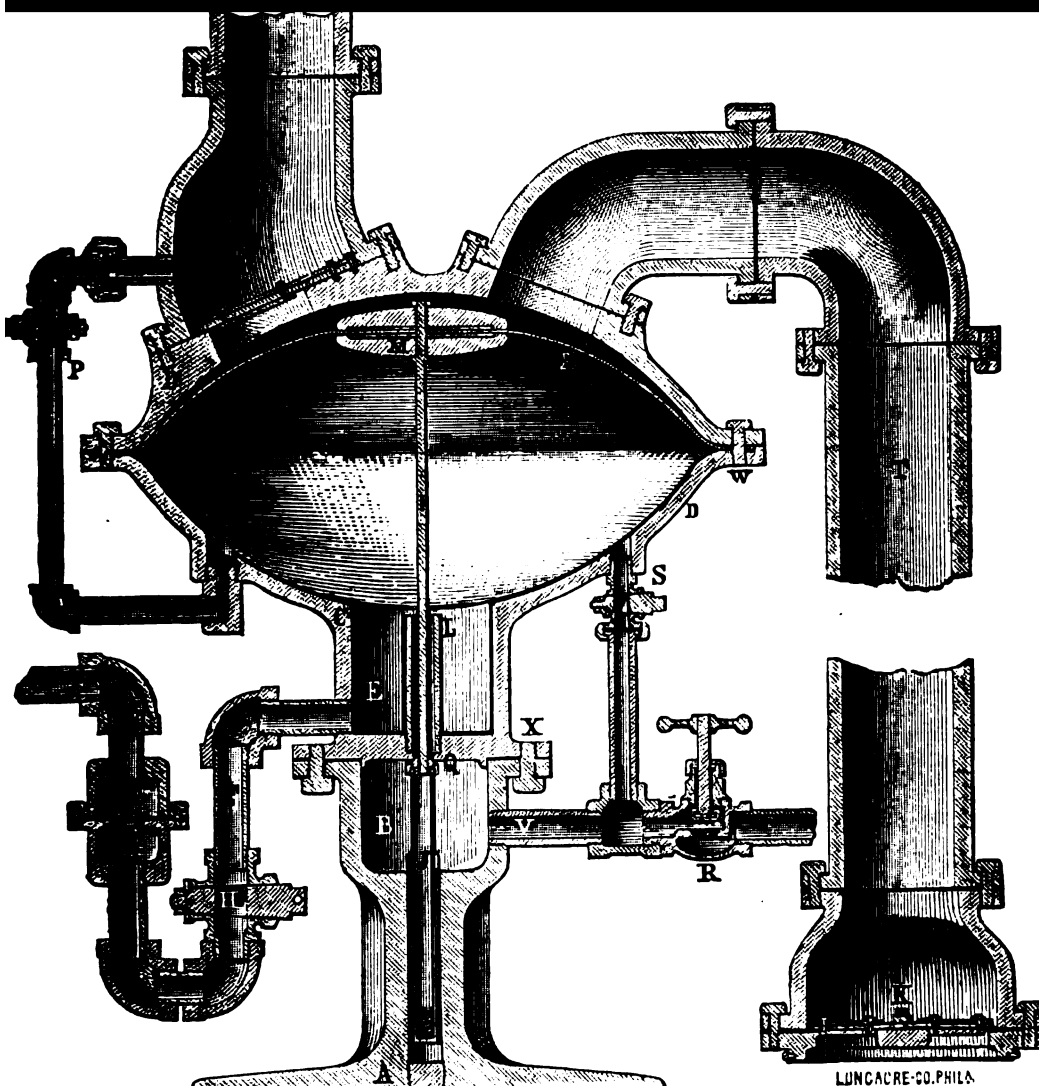
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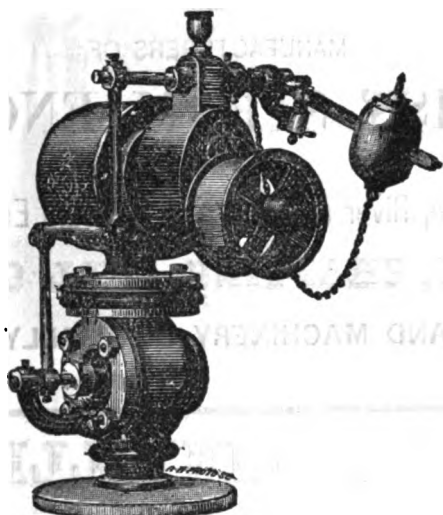
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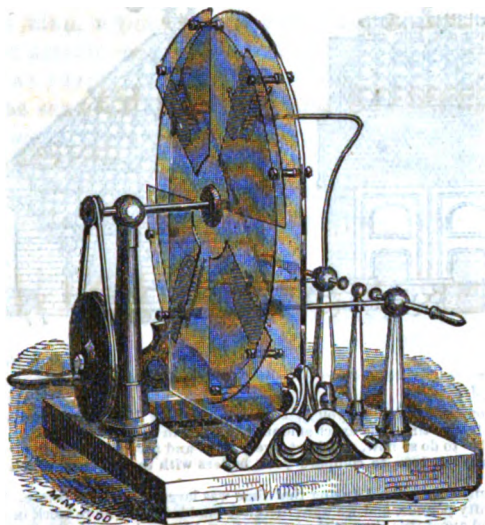
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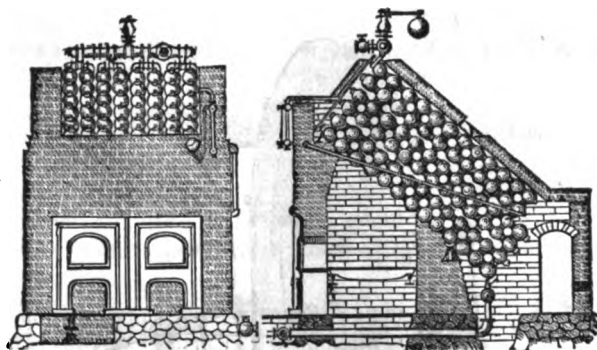
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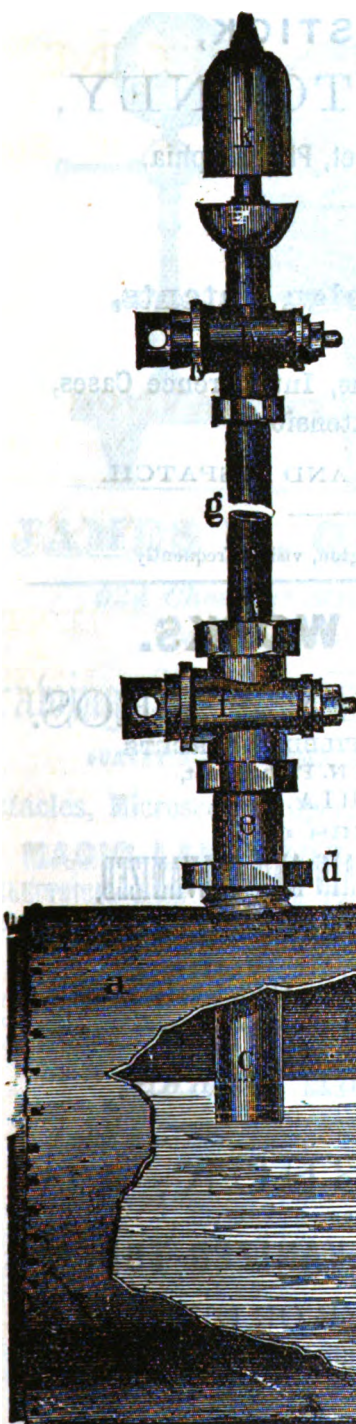
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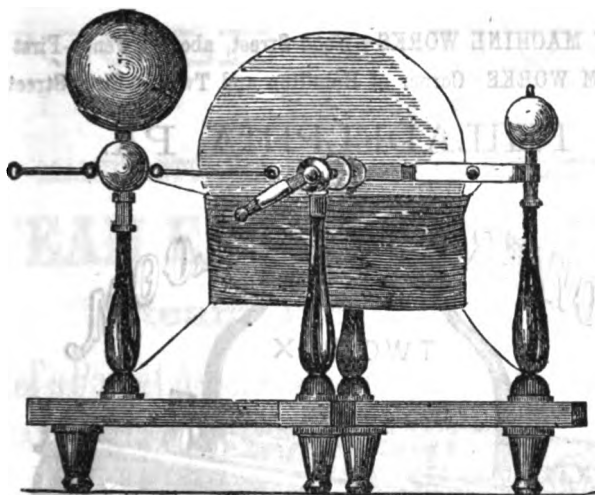
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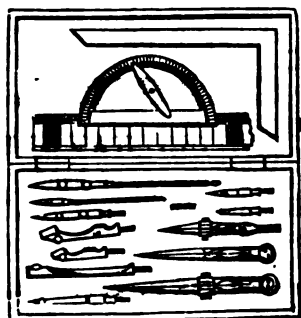
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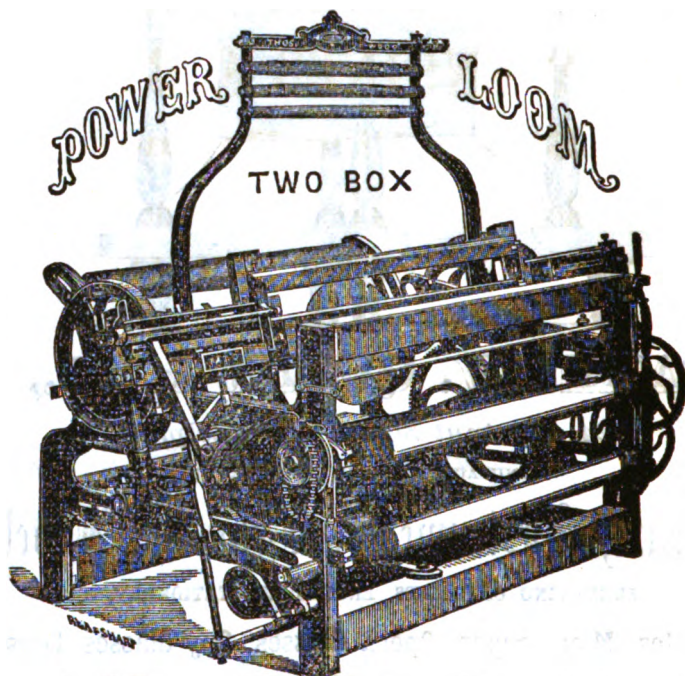
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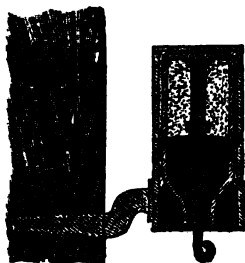
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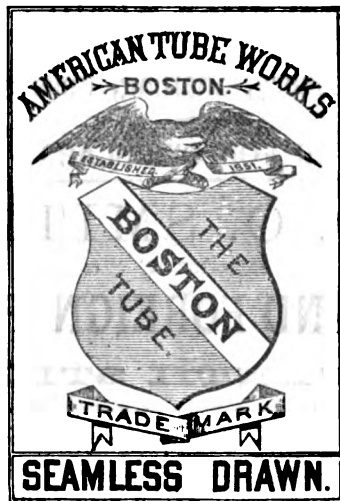


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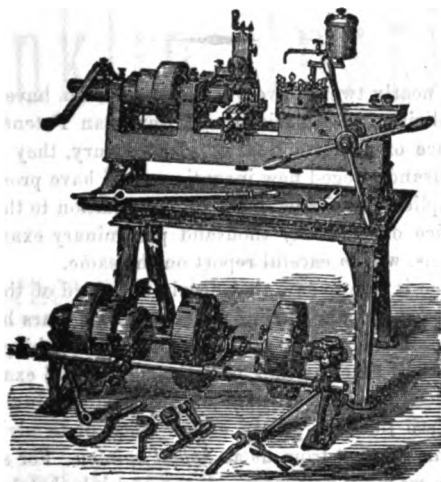
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JULY, 1869.

[No. 1

EDITORIAL.

ITEMS AND NOVELTIES.

Gunpowder Pile-Driver.—On page 218 of our last volume, we gave a full description, with an illustration, of this remarkable machine; we now give the report of some experiments made under the direction of Chief Engineer Wood, of the U. S. N.

Philadelphia, June 15th, 1869.

GENTLEMEN:—Having been present by invitation, at the shipyard of John W. Lynn, Esq., of this city, on the 14th inst., to witness the working and operation of Thomas Shaw's patent hammer for driving piles by the agency of gunpowder, and requested to report the action and details of the operation, we herewith briefly state the result to have been as follows:—

The pile-driving engine was of the usual form, being two vertical posts resting upon a platform, and readily moved as required.

The height of the posts was 48 feet, fitted with guides, and a frictional V-shaped rod, under the control of the operator, so arranged as to arrest the ram working in the guides, at whatever point desired.

The ram, working in the guides, was fitted with a plunger, extending through its centre and projecting above and below it about two feet.

The top of the pile was protected with a cast iron cap-piece, 30 inches deep, on the bottom of which was a recess resting upon and following it down during the process of driving it; into this cap-piece, upon its upper portion, was a cylindrical aperture, $4\frac{1}{2}$ inches in diameter and 18 inches deep, into which the lower plunger, attached to and forming a part of the ram, was fitted.

At the upper portion of the frame was located a cylinder, into which the upper plunger of the ram was fitted.

The operation being, that when a pile was placed in position to be driven, and but little space afforded for striking a blow, the upper plunger entered the cylinder at the top, compressed the air, and, by its elasticity, gave additional force to the ram in its descent upon the pile.

The hammer was put in operation by hoisting it up 6 to 8 feet, in which position it is held by the friction-bar, operated from below by a suitable lever. A cartridge is then thrown into the cylinder of the cap-piece, resting upon the top of the pile, by an attendant; when the hammer is released and falls, the plunger enters the cylinder of the cap and explodes the cartridge, which forces up the hammer a distance of from 7 to 9 feet, depending upon the size and weight of the cartridge.

The reactionary effort in projecting or throwing up the ram being utilized in forcing down the pile.

The weight of the ram, with the plungers, was 675 pounds.

The pile which we saw driven was very nearly parallel throughout its length; 12 inches in diameter, in the centre, and 32 feet long.

When placed in position, with its lower end pointed, eight blows were first given, to show the gentlemen present the operation of the machine, forcing the pile down 36 inches.

Nine (9) blows were then struck, forcing down the pile $20\frac{1}{2}$ inches. Time consumed, 15 seconds.

Next, twelve (12) blows were given, forcing down the pile 22½ inches. Time, 15 seconds.

Seven (7) blows followed, forcing down the pile 30½ inches.

The hammer then rested a distance of one foot above the head of the pile, at which point a blow was struck, which forced down the pile 1 inch.

At this stage of the operation, a cartridge one-half heavier than those previously used was placed in the cylinder, and, when exploded, forced the pile down 5½ inches, followed by two successive blows, when the pile was driven 12½ inches.

One blow, with similar cartridge, was struck, forcing down the pile 4½ inches.

The experiment was then made by striking the pile with the ram falling the same distance, 8 feet, from which it was thrown by the cartridge, dispensing with the cartridge, when the pile was driven only 1½ inches. The blow in this case being similar to that given by an ordinary pile-driving engine with a ram of 675 pounds falling through a distance of 8 feet.

The next blow was made similar to the last (with the use of the cartridge), the ram falling through 9 feet 6 inches, when the pile was driven 4½ inches, as in the former case.

A hard and well-seasoned oak block was placed upon the cap resting upon the pile, upon which the plunger fell when powder was not used.

The next experiment developed the rapidity with which the operation of driving piles with this machine could be prosecuted.

The pile was driven 10 feet 6 inches in 55 blows. Time consumed, 1½ minutes.

Eleven (11) blows were next given, forcing down the pile 26½ inches.

Twenty-nine (29) blows were next given in 40 seconds, driving down the pile 9 feet 2 inches.

The pile was next driven 2 feet, which completed the total distance driven, viz: 30 feet, of which no record was kept.

On the completion of the work, the cap was lifted off the pile, when the head was found to be in as perfect a condition as if, practically, no force whatever had been applied to it in forcing it through a distance of 30 feet in stiff, hard soil. It may be proper to add, in conclusion, we consider this novel application of gunpowder to be an unqualified success, for the purpose of driving

piles, promising, as it does, a saving both of time and labor, which should commend its use to all who require machines of this character.

We are respectfully your obed't servants,

To Messrs.

THOS. SHAW,
W. H. RICHARDSON,
W. L. GILROY,
JNO. W. LYNN.

W. W. W. WOOD,
Chief Engineer U. S. N.

H. L. HOFF,
Eagle Iron Works, Philadelphia.
T. J. LOVEGROVE,
Inspector of Steam Boilers, Philadelphia.

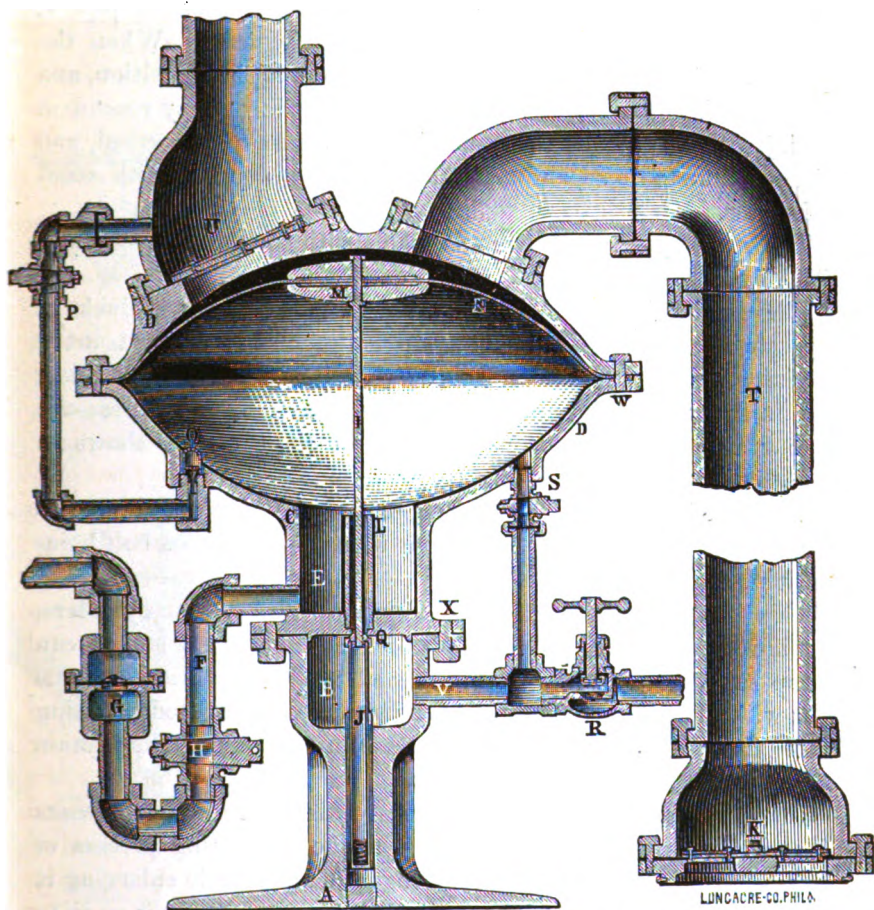
New Pumping Engine. By Messrs. Shaw & Justice.—At the last meeting of the *Franklin Institute*, this apparatus was exhibited, and described by M. Thomas Shaw, as follows:—

The appliances for pumping water are perhaps more numerous than those for the accomplishment of any other single purpose, and it might naturally be supposed that modern pumps could neither be cheapened nor simplified, to any great extent, for the reason that the hydraulic engineering talent of the world, for the past half century, has been spent in improving these machines; yet, notwithstanding this, I believe that the pump I am about to explain, when constructed of large size, can be furnished at less than one-half the cost of any other pumping engine, will perform the same duty, and possesses not a tenth of the complication of parts.

This engine is constructed in the following manner:—two hemispheres, c and d, are united by bolts, w, and between them is a cotton duck and gum diaphragm, n, clasped in the centre by metal discs, m, secured to valve-stem, i. A is a cast iron base, united to hemisphere, c, by bolts, x, forming a steam-chest, B. v is a steam-pipe leading from the boiler, and r and s are valves to control the same. j is a valve, having its seat at q, and is operated by the valve-stem, i, as hereafter described. t is the inlet-pipe, provided with ordinary valves, k. u is the outlet-pipe, provided with a valve. p is a pipe, provided with a stop-cock, to lead water to the injecting nozzle, o; said nozzle is provided with a valve opening inward. e is the hot well for the collection of the condensed steam. l is a pipe for conveying steam above any water contained in the hot well. f is a pipe for conveying water from the hot well, and is provided with a valve, g, and stop-cock, h.

The engine is started in this wise: steam is allowed to pass from valve s into the hemispherical chamber beneath the diaphragm, n,

until all the air contained in said chamber is blown out through pipe F, when the steam is shut off at valve s. When the hemispherical chamber is relieved of pressure below that of column of water in pipe, P, jets of water are thrown from nozzle, o, condensing the steam and creating a vacuum. The only place to fill this vacuum is by the inlet-pipe, T, through which the water rushes and fills the



hemispherical chamber above the diaphragm, until it forces the diaphragm to its lowest position, at which time the valve-stem will have reached the bottom of valve, J, and press upon a spring contained therein, forcing the valve from its seat and allowing the steam to pass through pipe L, beneath the diaphragm, forcing all the water out of pipe U, until the diaphragm shall have arrived at

its highest position, at which time the button in lower end of valve-stem will have caught on the top of valve J and lifted it to its seat, where said valve will be held by the pressure of steam until again pushed off. In the meantime, during the ascent of the diaphragm, the injecting-nozzle, O, will cease injecting water at the instant the steam enters, by reason of the pressure of steam, and the hot water from the previously condensed steam will be forced out of pipe R, by reason of the pressure of steam upon the same. When the diaphragm has arrived at the afore-described highest position, and the valve shuts the steam off, a vacuum will be formed by reason of the injected water; and the pump operates as before described, and will continue to do so, automatically, so long as supplied with steam and water.

The interior of hemisphere C is coated with non-conducting material, to prevent loss of heat.

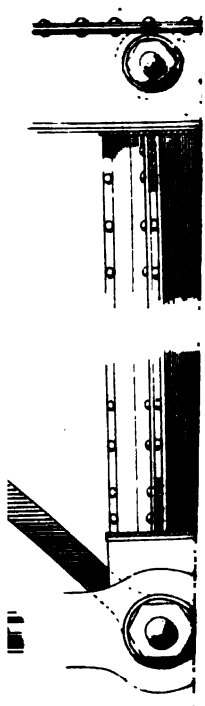
The diaphragm is constructed of thick gum and cotton duck, in separate layers, and is used only as a partition for heat; it floats in the pressure without strain, as the pressure is the same on both sides; and, in this respect, it is not unlike a belt traveling in the pressure of our atmosphere. A continued use of eight months shows no appreciable wear.

We have here a pump which is constructed in the foundry, so to speak, since all the fitting to be done is in the nature of bolt-holes and pipe apparatus.

This is a pump that at once dispenses with bored cylinders, piston-rods, and all these complicated appliances; one that can pump sandy water without cutting, and needs no lubrication; one that will allow the whole force of the steam to be exerted in lifting water, and will not consume one-quarter in overcoming the friction of parts as in other pumping engines.

Punched Steel and Iron Tubes.—It is upwards of two years since we first publicly drew attention to the interesting process of making tubes by punching a solid ingot and gradually enlarging it afterwards by punches of successively increasing diameter so as to put the work upon the tube from the inside, instead of, as heretofore, longitudinally. Messrs. Deakin & Johnson's punched tubes have since achieved a great commercial success. Upwards of a quarter of a million have been made; and in many large contracts abroad, especially for the Kensington rifles, no others are used.—*Mec. Mag.*

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Broom and Tool Holder.—At the last meeting of the *Institute*, there was exhibited a simple and ingenious contrivance for the above purpose, devised by Mr. John G. Powell, and manufactured by Frank S. Judd & Co., of this city. It consists of a soft metal socket, cast upon an ordinary wood screw, with a piece of steel wire so bent and inserted as to clasp and hold securely any object, such as a broom or tool-handle, pressed into its grasp. The manner in which the wire, by a series of bends, is made to fulfil the various offices of securing itself in the socket, grasping the handle, and springing sufficiently to clasp objects of various size, is deserving of high commendation, as also is the structure of the mould in which the sockets are cast, which involves several important features of adjustment.



The accompanying cut shows one of these holders in position, with a handle of a clothes-brush in it. It must not, however, be supposed that a depression in the handle is requisite. It will hold a straight wooden broom-handle just as well.

Proposed Iron Bridge over the Schuylkill River at Fairmount.—By a resolution of Councils, premiums were offered for designs for an iron bridge at Fairmount, and the City Engineer was instructed to advertise for plans and estimates.

The design illustrated in this number of the *Journal*, was submitted by J. H. Linville, C. E., Philadelphia, to whom was awarded the first premium.

The bridge will occupy the site of the present Suspension bridge, the lower roadway accomodating the travel on Callowhill and Haverford streets. The upper roadway will be approached on the west by an iron viaduct on columns, in accordance with designs prepared by the Chief Engineer of the City, carrying the traffic from Bridge Street over the Pennsylvania Railroad tracks. A similar viaduct at the eastern approach will be continued through the Reservoir enclosure, and terminate in Spring Garden Street. The clear span of the bridge is 340 feet, total width 50 feet, and heighth of truss over all, 35 feet. The sidewalks are each 8 feet in width.

The variable load assumed is 75 pounds per superficial foot of upper and lower floors, 7,500 pounds per lineal foot of superstructure. With this load uniformly distributed, the several parts of the trusses will be strained to one-sixth of their ultimate strength. The style of truss adopted is known as the Linville & Piper patent wrought iron truss, embracing their patent upper chords of plates and channels, tubular wrought iron posts, and "upset" lower chord links. The vertical and horizontal members of the trusses are connected with the suspension diagonals or links by turned connecting pins. The trusses are stayed laterally, by an arrangement of wrought iron lattice bracing, ornamented by cast iron brackets and pendants.

The footwalks, carried on projecting cantilevers, are protected by suitable iron railings, and finished with ornamental facias, shields and scroll-work. The flooring consists of two courses of 2½-inch oak plank, secured to iron joists.

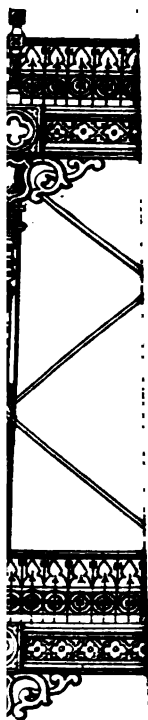
All parts of the iron work will be accessible for repainting. The wood work will be treated by the Robbins preservative process.

When the bridge, with its long approaches on ornamented iron columns, has been completed, the present dangerous grade-crossing of the railway tracks will be obviated, and Spring Garden Street will have a direct connection with Bridge Street. The entire structure will be of the most substantial and durable character, in style and proportion worthy of a great city, and a pleasing object in the vicinity of the Park.

Committee on Plans.—Strickland Kneass, Chief Engineer and Surveyor of Philadelphia; Herman J. Lombaert, 2d Vice-President Pennsylvania Railroad Company; Edward Miller, Civil Engineer, &c.; Solomon W. Roberts, Chief Engineer North Pennsylvania Railroad.

French Atlantic Telegraph Cable is rapidly approaching completion; the whole of the gutta-percha core has been finished at the works at Wharf road, and of the total length of the cable, one section, that from St. Pierre to Boston, has been completed at Mr. W. T. Henley's works, at North Woolwich. The larger section, from Brest to St. Pierre, now making at the Telegraph Construction Company's works at Greenwich, has made such rapid progress that there is no doubt but that it will all be completed to time. The total length of both sections manufactured to May 1st was 3,350 miles, and of this length nearly 2,700 miles had been shipped.

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Three vessels are now receiving cable, the "Great Eastern," with over 2,100 miles of main deep sea cable on board; the "Scanderia," with 450 miles of the United States section; and the "William Cary," with only, as yet, a short length. It is anticipated that the "Great Eastern" will leave Sheerness about the second week in June, but before that time we hope to place before our readers some further interesting details of this truly great enterprise.—*Mech. Mag.*

British Indian Telegraph.—Immediately after the completion of the core for the French Atlantic cable, at the gutta-percha works, the conductor for the British Indian line was commenced to be insulated, and before the "Great Eastern" can leave, the machines at Greenwich will be in full work manufacturing this cable, which will be a few miles longer than the French Atlantic cable. This cable will also be in two sections, the one from Suez to Aden, and the other from Aden to Bombay—a total length of 3,600 miles. The two sections differ from each other in the size of core and in external protection; but on the commencement of the work we shall be able to give some particulars.—*Mech. Mag.*

On the Practical Speed of Electricity through 7,200 miles of Land Wire. By G. Davidson, Esq., Astronomer, United States Coast Survey.

Observations to the above end were made on the night of Feb. 28, 1869, at San Francisco, California, on a loop of wire extending thence to Cambridge, Massachusetts, 3600 miles, and returning to San Francisco; the return signal being received on a chronograph close to that receiving the outgoing signal.

The total interval of time between the records of the two signals amounted to 0·8 of a second; and this may be called the *practical* speed through 7,200 miles of land wire, because that length was cut up in the usual service manner of telegraphic companies, into 11 portions, say, of 650 miles each; these portions being connected by as many relays (or repeaters, as they are called in America,) which send forward on each of these occasions a new electrical current into the next section of the wire; and such new electrical current would travel through its new 650 miles of wire much more quickly than an original current through the second, third, or any subsequent continued length of 650 miles.

The integral result may, therefore, be looked on as a safe and satisfactory multiplication by 11 of the time occupied by electricity

in both traveling through 650 miles of land wire, and working *one* relay of the kind, whatever that may be, now used in the United States; the time occupied in effecting such work being apparently 0·07 of a second.

New Paper for New Uses.—We all know to what gigantic proportions the new industry implied in the term “paper collar” has grown, but a new material which has just been introduced bids fair to cast this entirely into the shade, and to exert a very important influence upon the textile manufactures of the world. A material known as felted paper has been devised by M. Pavy, composed of New Zealand flax, jute, mallow, and the ordinary fibres of hemp and cotton, as well as some wool, silk, skin, &c., which are all reduced to “pulp,” and treated in the usual way for paper-making.

They produce a material of wonderful pliability and tenacity, about which and its uses our cotemporary, the London *Mechanics' Magazine*, expresses itself as follows:—

“It can be sewn together with as much ease, and makes as strong a seam, as the woven fabrics it is intended to replace. The uses to which this paper can be put are innumerable. We may mention a few of the articles we have seen at the office of Messrs. Roberts and Thorne, 82 Gracechurch street, City. First, petticoats, which no ‘girl of the period’ could resist. These may be printed exactly like the skirts now so fashionable, or they may be white, and have open-work stamped out in patterns, which scarcely any amount of labor with scissors and needle could imitate. The marvel is that they can be sold retail for sixpence each—little more than the cost of washing a petticoat. We have, next, bed-furniture of imitation cretonnes and chintzes. These are printed with patterns of great beauty, and a set of curtains will only cost five shillings. We have also quilts, which, besides being excellent non-conductors of heat, have a very ornamental appearance. White day-covers for beds are made with embossed patterns, and equally cheap. White table-cloths, stamped with patterns in remarkably good taste, will, we are sure, soon ornament many a dinner-table, and serve to light the fires the day after the party, unless the host be of an economical turn and re-sells them to the paper-maker. But the material is also applied to articles of a more substantial character. Very good imitation leather is formed of it, and furniture-covering, and even shoes may be made. The last can be made impermeable to wet, by the introduction of oils and india-rubber. We have said enough to show

that a material is produced which will probably have considerable influence on some of our staple industries. Paper collars, it may be well supposed, have already had a sensible influence on the linen trade, and the further extensive substitution of paper for woven fabrics must produce still greater changes."

Gold Refining,—a New Process.—A new way of effecting the separation of the silver, in gold refining, has been recently introduced into the Mint at Sydney, Australia.

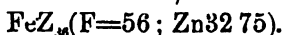
In order to carry out the operation, a clay crucible is first prepared with borax, by dipping it into a hot saturated solution of the salt, and afterwards thoroughly drying it; all the pores of the crucible being by this means filled. The alloyed metal is melted in the crucible thus prepared; a small quantity of borax being added during the process. A stream of chlorine gas is then caused to pass through the fused mass, and by uniting with the silver forms a chloride of silver, which rises to the top, and remains liquid after the purified gold has been cooled to such a degree as to become solid. After this the molten chloride is poured off, and the silver reduced by the usual chemical process. The previous saturation of the crucible with borax, is found to prevent it from absorbing the chloride, and obviates the loss which would otherwise result from the passage of the liquid chloride through the porous material of the crucible.

Preserving Silver.—The loss of silver which results from the impregnation of our atmosphere with sulphur compounds, especially where gas is burned, is very great. It has been said that many thousands of pounds worth go down our sewers annually in the form of dirt from plate-cleaning, and the loss of one large house on Cornhill, from this source, has been described to us as serious. Silversmith may, then, thank one of their confraternity, Herr Strolberger, of Munich, for a happy thought. He seems to have tried various plans to save his silver, if possible. He covered his goods with a clear white varnish, but found that it soon turned yellow in the window, and spoilt the look of his wares. Then he tried water glass (solution of silicate of potash), but this did not answer. He tried some other solutions, to no purpose; but at last he hit upon the expedient of doing his goods over with a thin coating of collodion, which he finds to answer perfectly. No more loss of silver, and no longer incessant labor in keeping it clean. The plan he adopted is this:—He first warms the articles to be coated, and then

pays them carefully over with a thinnish collodion diluted with alcohol, using a wide soft brush for the purpose. Generally, he says, it is not advisable to do them over more than once. Silver goods, he tells us, protected in this way, have been exposed in his window more than a year, and are as bright as ever, while others, unprotected, have become perfectly black in a few months.—*Mech. Magazine.*

Silver Plating Solution.—A non-poisonous silver solution—non-poisonous, at all events, in comparison with the cyanide solution, which allows no time for the use of antidotes—though not, possibly, altogether harmless, may be found useful, especially when it can be applied without the use of electricity. The inventor takes one part of nitrate of silver and dissolves it in twenty parts of water. To this solution he adds half a part of sal-ammoniac, and precipitates the silver as chloride, which he again dissolves by the aid of two parts of hyposulphite of soda. Afterwards, he adds to the clear solution two parts of a milk of chalk and water. When used, the mixture is shaken up, a little poured into a saucer, and rubbed over the article to be silvered with a tooth-brush or a linen rag. After rubbing a short time, and rinsing with water, the article, it is said, will be found beautifully silvered.—*Mech. Mag.*

On an Alloy of Iron and Zinc.—It is a well-known fact that Iron is dissolved by molten zinc, but nowhere is any definite alloy of these metals described, nor is it also stated how much Iron is dissolved by Zinc. Dr. Oudemans, Jr., obtained from analysis a piece of metal which had been formed in an iron vessel wherein zinc had been fused for several weeks continually; this metal was found deposited at the bottom of the vessel, and became an impediment to the melting operations in consequence of the relative infusibility of the alloy. In physical aspect this latter was of very much whiter color, and entirely different crystalline structure from zinc; the alloy dissolved very readily and briskly in dilute sulphuric or hydrochloric acid, and was found, on analysis to contain 4.6 per cent of iron. Taking for granted that this alloy is a definite compound of the constituent metals, its formula would be—



Further Researches on Jargonium, and Ceylon Jargon. By H. C. Sorby, F. R. S., &c.—In my last note I told you that I had found in zircons what appeared to be another elementary substance. I have, since then, made many experiments, and find

that the facts are far more interesting than if they were the effect of a new element. Judging from analogy with all other known substances, no other conclusion could have been formed; but I now find that jargonite exists in two distinct conditions, which have different specific gravities and optical properties. The flamed borax beads give two entirely different spectra, according to the temperature to which the enclosed crystals have been exposed; and there is an analogous difference in the silicates. On taking a pale green jargon, which, naturally, showed a mere faint trace of the absorption bands, and keeping it at a bright red heat for some time, the specific gravity gradually increased from 4.20 to 4.52, and the spectrum then showed all the narrow black absorption bands in as great perfection as my best specimen. This fact is, of course, very interesting, since we can now artificially alter jargons so as to show the bands in the same splendid manner as a few do naturally, and shall thus be able to obtain them without much difficulty, to use as a most excellent natural standard scale, to measure the position of the absorption bands in other spectra.

Eclipses of 1868 and 1869.—In an article upon the eclipse of last year, we noticed (p. 270 of our last volume) De la Rue's calculation of the rotary motion of the great horn. As was there stated, these calculations were based upon certain drawings published in the *London Engineer*. From an article in the Monthly Notices of the Royal Astronomical Society, we just learn that one of these is entirely incorrect, showing an inclination northward where it should have been southward. This, of course, destroys the conclusions as to an axial rotation founded upon the published drawings.

By a curious oversight, the date given by us in the same article (page 273) for the coming eclipse was the same as the one before; it should have been August 7th.

Aqueous Vapor in the Sun.—In a late number of the *Comptes Rendus*, we find a letter from Father Secchi, which contains some statements of so remarkable a character that nothing but such high authority could give them credibility. He tells us, that in examining the light from the vicinity of large sun spots, with a powerfully dispersing spectroscope, in which the incident and refracted beams are nearly parallel, he has frequently met with groups of nebulous bands in the region of red and orange, about 809.5 and 864 of Kirchhoff's scale.

The bands are very distinct from those of the normal spectrum,

and not at all likely to be confused with them. They seem to be made up of many very fine lines, enveloped in a nebulous shade, and appear on the penumbrae of large spots, and on the trains of small ones often found. They are never perceived on the general solar surface. On one occasion, they were observed when the general surface was in field, but it was then found that a light cirrus cloud was between the observer and the sun. This observation was repeated, and leaves no doubt that these lines are due to the absorbing action of vapor of water.

The Yellow Ray of the Prominences Reversed in the solar spectrum. Father Secchi also announces, that with a spectroscope of nine prisms, he finds a dark band exactly corresponding in position with the yellow ray near D, observed in the spectrum of the prominences and chromosphere. This same band he also found in several stars whose spectra bear a general resemblance to that of the sun. Thus it appeared in Aldebaren, Orion and Polux. Sirius presented a bright region in the corresponding place. In the red stars of the fourth class, *bright* yellow rays may be seen, but it is difficult to fix their position.

Proper Motion of Stars Measured with the Spectroscope.—Father Secchi has repeated and confirmed the observations made by Mr. Huggins on this point (see our last number, page 375,) and has also been able to see the two other bands corresponding with hydrogen, which he finds to be similarly displaced with the F line.

Another Burning Star.—We have, at various times, referred to the curious phenomena attending the outburst of a star in the Northern Crown during May, 1866. (See Vol. LVII., p. 159, and Vol. LII., p. 138.) It now appears that another variable star, R in Gemini, which attained its greatest brightness (5.5) in February last, has been examined by Father Secchi, and finds its spectrum closely analogous to that of the first-mentioned star. It shows a *brilliant* hydrogen ray, and other bright lines, of which the principle ones correspond with the dark bands in a Orionis, between B and D.

The Tower Subway is advancing at the rate of nine feet per day, and the contractor expects to reach the shaft on the Southwark side in less than five months.

Beanes' Process for Bone Black.—On page 398 of our last volume the reference should be to page 423 not 428.

Civil and Mechanical Engineering.

STEAM JACKETTING CYLINDERS OF CORNISH PUMPING ENGINES.

BY HENRY P. M. BIRKINBINE, C. E.

It is almost the universal practice in constructing Cornish pumping engines, to surround the steam cylinder with another cylinder, leaving an annular space of about one inch; this space, when the engine is working, is kept filled with steam from the boilers. The steam jacket is considered by most engineers an indispensable part, and it is claimed that with it, an engine can be worked to a higher degree of expansion, and with greater economy of fuel, and that without such an appendage the walls of the cylinder cannot be maintained at an equal temperature and parallel.

Watt, it is said, abandoned the use of the steam jacket for a time, but used it again, believing the efficiency of his engines was improved thereby.

Having had experience in constructing engines of this kind with and without jacketted cylinders, I have been led to question the value of the steam jacket in effecting any economy of fuel, and to doubt whether it does not rather take from the efficiency of an engine. Being an expensive appendage, and, unless carefully handled, liable to get out of repair, it should be abandoned if unnecessary.

The following practical statements may present some facts to sustain the position taken in opposition to high authorities and almost universal practice; remembering that all the power of the engine, whether exerted in the cylinder directly under the piston, or from the jacket through the walls of the cylinder, is drawn from the boilers, it is the utilization of the amount of caloric which is converted into force by the reduction of the steam into water.

The loss of heat in a steam cylinder is—

First.—By radiation from the outside surfaces.

Second.—Heat converted into work by the engine.

Third.—Refrigeration by the condenser.

Outward Radiation from the Cylinder.—This is entirely prevented by the steam jacket, as it is maintained at about the same temperature as the steam in the boilers, which is in excess of that in the cylinder, where expansion is used.

But the outside of the steam jacket will radiate more heat than the steam cylinder, because of its greater circumference, exposing a larger amount of surface, and because it is maintained at a higher temperature. In ordinary practice, the mean temperature in the cylinder is 202°F. , and that in the boiler communicating with the steam jacket is 274°F. The careful protection which the cylinders of this class of engines generally receive, prevents radiation from being a source of much loss.

Heat converted into work.—There is no doubt that a higher degree of expansion is possible with a steam-jacketted cylinder, for as the temperature of the steam in the cylinder is lowered, heat is imparted by the steam in the jacket, and the expansion is thus carried to a greater extent. But whatever heat is thus imparted, must be furnished from the boiler. The proposition then becomes this: will the heat, imparted by the steam in the jacket, do more work than if supplied to the steam cylinder directly, either by admitting steam at a higher temperature, or a greater volume of it?

Refrigeration by the condenser.—In single-acting engines, such as the Cornish, the loss is much less than in double-acting engines, as the steam end of the cylinder is never directly connected with the condenser, the steam (usually at about 202°F.) passing through the equilibrium passage into the other end of the cylinder before the exhaust is opened. When the exhaust is open, the inside surface of the cylinder is exposed to the cooling effect of the condenser, and the steam in the jacket is robbed of heat during the entire indoor stroke, or while the steam is doing its work on the opposite side of the piston. This not only wastes power, but throws additional labor on the condensing apparatus.

The objection made that the cylinder will become larger at one end than at the other while in use, because one end connects with the boiler and the other with the condenser, is merely a technical one; for if no heat be conducted from the steam end to the exhaust end by the iron in the cylinder, the difference of temperature is so small, that when represented by the difference in diameter caused by the expansion of the metal, it could not be measured by ordinary means. There is practically none.

The accumulation of water in the cylinder is either the result of loss of heat by the walls of the cylinder, or of excessive expansion or of *priming*. A steam jacket would reconvert any water in the cylinder into steam, if it was in contact with the sides of the cylinder, but as this water would rest upon the piston-head in an ordinary "beam" engine, and upon the lower cylinder head in a "Bull" engine, the heat from the jacket would not act directly upon it, and the process would necessarily be a slow one. Whatever heat is thus imparted, must be taken from the steam in the jacket.

The water can be removed probably as effectually and economically by admitting the steam into the cylinder at a temperature sufficiently above that necessary to perform the work, to absorb all the water. There may have been difficulty in doing this where steam was used at the low pressure of from four to ten pounds, but it can readily be accomplished when the practice is to maintain a pressure of from 30 to 45 pounds.

NEW BLACKFRIARS BRIDGE.

WE are sorry to say that now all hopes of completing this magnificent thoroughfare in time for opening by the 24th of this month are at an end. The bridge cannot now be ready for opening before the end of June. This is to be regretted, because the most unceasing efforts have been made to get all forward so as to allow of the inaugural ceremony being held on the 24th inst. There would have been a peculiar fitness in giving up this splendid work to the public on that day, for the 24th of this month is the 50th anniversary of Her Majesty's birth, and it is exactly the 100th anniversary of the date on which old Blackfriars bridge was first opened. Two such coincidences, therefore, seemed to make it imperative that the bridge should be opened on that date, and on none other; and Messrs. Thorn, the contractors, have done their utmost to secure such a desirable result; but it was not to be. Difficulties which no human ingenuity could have foreseen or lessened arose, so that the idea of opening this month was gradually and reluctantly abandoned, and the date is now postponed to some day not yet named, at the end of June or the beginning of July. Even if completed at this date, however, it will be among the quickest built permanent bridges ever stretched across the Thames. The works were begun

in June, 1864,—that is to say, the old bridge was closed at that time. It took eighteen months to remove that ruinous dilapidation, and it was not till the January of 1866 that the present structure was commenced. It will thus, in June, have taken three years and a-half to complete it from first to last. Old Blackfriars was commenced in 1760, and finished, as we have said, in 1769. Vauxhall bridge was begun in 1811, and finished in 1816; Waterloo bridge was also begun in 1811, and finished on the 18th of June, 1817, the second anniversary of Waterloo, after which victory the bridge was called; Southwark bridge took six years to build, Hungerford five years, old Westminster eleven, and new Westminster, from one cause or another, very nearly the same time. London bridge took seven years before it was completed. So that if we get Blackfriars bridge in three years and a-half from its commencement, we shall have no cause to complain of its engineers or of the speed with which the contractors have done their work under them.

As far as regards the structure, the new bridge may be said to be absolutely complete. All the iron ribs of the arches are "bedded" and bolted together. These arches of wrought iron were, of course, built in separate ribs, but were not laid on the stone-work of the piers, and rested entirely on the timber centering, with their ends about three-quarters of an inch from the stone piers, from which they were wedged up. These wedges have now been knocked out, and the arches allowed to settle down into their places on the stone. No bed-plates were used, but between the iron and the stone-work molten lead was run in, and when this had hardened the wedges were knocked away, the iron ribs at once came to their proper bearings, and in no instance was any perceptible deflection observed when the arches were thus left to carry their own weight. The centering is now simply retained in its place for the accommodation of the painters, who are about to paint the whole structure. The iron-work has already had two coats of paint; the last, which is now being given to it, is of a rich bronze green. The outer iron span-drills of the arches are covered at the intersections of the lattice-work with large ornamental bosses, much after the pattern of the well-known heraldic rose. These decorations are to be richly gilt, and the color contrasts which will be afforded by the gilding, the bronze green, the red polished granite, and the white carved stone-work, will make this bridge, as seen from the river, one of the most beau-

tiful works of its kind. Every one of the granite columns have now been fixed. They are the largest ever used in any bridge. Each of them cost more than £800, for they are nearly 24 feet in circumference, and have been polished to the smoothness of an agate surface. Each column stands on a richly-carved pediment of white Portland stone, and each is surmounted by a most massive capital carved in birds, flowers, and sea and river weeds. Four of these capitals have been finished by Mr. Phillips, and their effect is really splendid. The other four are well in hand, and will, it is hoped, be ready when the bridge is opened. Above these capitals will be placed the carved recesses. There are to be four of these on each side of the bridge, so that the somewhat bare and monotonous outline of parapet at Westminster is avoided. Each of these eight recesses are to be 10 feet deep by 13 feet wide. They will be fitted with plain granite benches, but the outer or river side will be carved with quatre-foils deeply cut, but not pierced through. In such a highly ornamental structure as this is to be, it is satisfactory to know that the lamp-posts are to be as artistically treated in form and ornamentation as the rest of the work. These standards are not to be fixed on the parapet, as has always been the case hitherto, but will be in close lines along the curb at each side, so as to throw the greatest amount of light over the broad pavements and over the still broader roadway for the use both of the vehicles and pedestrians. In each of the recesses, however, branched lamps will be placed as beacons to warn the passing river traffic by night where the sharp-edged piers are. About two-fifths of the whole bridge have already been paved with its buckle-plates, and sufficient has been done to form a fair path across the whole bridge, while the two shore arches are quite finished. The abutment on the Surry side has also been quite finished. Nearly all the ornamental parapet work has been delivered at the bridge, but only a few short lengths have been placed in position. It is a very beautiful specimen of Venetian gothic, in its most florid style, and does great credit to the founders. From the inside of the bridge this parapet will appear rather low, being only 3 feet 6 inches in height. From the river, however, it will look bold and sufficiently lofty, as it will stand on the summit of a rich cornice. Next week the work of taking down the scaffolding will be commenced in some parts, and in others the piles around parts of the structure will be drawn. There are, altogether, nearly 6,000 loads of this timber to be removed above and below water, but it is calculated that all may be got away within a

couple of months. Directly the new bridge is opened, the work of pulling down the temporary wooden one alongside it will be proceeded with. This temporary bridge remains as strong as ever. It is, in fact, a temporary bridge only in name, for, with repairs to piles now and then, it would last as long, almost, as old Blackfriars bridge, which, for nearly half the time that it stood, was in a state of chronic dilapidation and decay. The new bridge will cost, altogether, about £320,000, or at the rate of about £4 the superficial foot. At this rate it will be one of the cheapest permanent bridges yet built in London.—*Times*.

A TRACTION ENGINE AT NAMAQUALAND.

THE dullness of this place and Springbok has been greatly and agreeably disturbed by the running of the Cape Copper Mining Company's steam traction engine "Pioneer" along the roads, and great was the astonishment of some of the country people to see an immense (as they called it) fire-wagon traveling without either horses or oxen. It is devoutly to be wished that many more of the same kind of engines may follow, as it is deplorable to see many thousands of tons of copper ore lying upon the company's grounds without the means (unless by the old process) of being transported to a port of shipment. The engine was made by Aveling & Porter, and combines the latest improvements suggested by their great experience in this class of machinery. The trial-trip from this place to Springbok was made on the 19th March, the engine leaving Ookiep early in the afternoon, ascending with ease the steep gradient at the toll-gate, passing through the village to the reduction works, and returning to Ookiep the next day. On the following Tuesday, under the management of Mr. W. Morshead, the company's resident engineer, a more severe trial was made, the engine, in the presence of the company's superintendent, ascending a steep hill on the Nababeep road, the path being in places very rocky and cut up by water-courses. In returning to Ookiep, an old wagon-road was taken in which a deep "sluit" was met with. This, also, was easily crossed. The engine seemed, in fact, able to make its way almost anywhere that an ox-wagon could be driven, and it will, doubtless, render valuable assistance in the transport of ores and materials.—*The Cape Argus*, April 3, 1869.

BELTING FACTS AND FIGURES.

By J. H. COOPER.

(Continued from Vol. LVII., page 382.)

Opinions respecting the Comparative Merits of Gearing and Belting.

"CONSIDERABLE difference of opinion exists as to the best and most effective principle of conveying motion from the source of power to the machinery of a mill. The Americans prefer leather straps, and large pulleys or riggers.

"In this country, and especially in the manufacturing districts, toothed wheels are almost universally employed.

"In some parts of the South, and in London, straps are extensively used; but in Lancashire and in Yorkshire, where millwork is carried out on a far larger scale, gearing and light shafts at high velocities have the preference.

"Naturally, I am of the opinion that the North is right in this matter, and that consistently, as I was to a great extent the first to introduce that new system of gearing which is now general throughout the country, and to which I have never heard any serious objection, I have been convinced by a long experience that there is less loss of power through the friction of the journals, in the case of geared wheel work, than when straps are employed for the transmission of motive power. Carefully conducted experiments confirm this view, and it is therefore evident which mode of transmission is, as a general rule, to be preferred."

"There are certain cases in which it is more convenient to use straps instead of gearing. With small engines driving saw mills, and some other machinery where the action is irregular, the strap is superior to wheel work, because it lessens the shocks incidental to these descriptions of work. So, also, when the motive power has been conveyed by wheel work and shafting to the various floors of a mill, it is best distributed to the machines by means of straps."

"In some of the American cotton factories, however, there is an immense drum on the first motion, with belts or straps from two to three feet wide, transmitting the power to various lines of shafting, and these in turn through other pulleys and straps, giving motion to the machinery.

"From this description it will be seen that the whole of the mill is driven by straps alone, without the intervention of gearing.

"The advantages of straps are the smoothness and noiselessness of the motion. Their disadvantages are cumbrousness, the expense of their renewal, and the necessity for frequent repairs. They are inapplicable in cases where the motion must be transmitted in a constant ratio, because, as the straps wear slack, they tend to slip over the pulleys, and thus lose time. In other cases, as has been observed, this slipping becomes an advantage, as it reduces the shock of sudden strains, and lessens the danger of breaking the machinery.

"Very various materials are employed for straps, the most serviceable of all being leather spliced with thongs of hide or by cement. Gutta percha has been employed with the advantage of dispensing with joints, but it is affected by changes of temperature, and it stretches under great strains. Flat straps are almost universally employed, in consequence of the property they possess of maintaining their position on pulleys, the faces of which are slightly convex.

"Round belts of cat-gut or hemp are sometimes used, running in grooves, which are better made of a triangular than a circular section—so that the belt touches the pulley in two lines only, tangential to the sides of the groove; in this case the friction of the belt is increased in proportion to the decrease of the angle of the groove."

"The strength of straps must be determined by the work they have to transmit. Let a strap transmit a force of n horse-power at a velocity of v feet per minute, then the tension on the driving side of the belt is $\frac{33,000 n}{v}$ lbs., independent of the initial tension producing adhesion between the belt and pulley. For example, let v be 314·16 feet per minute, or the velocity of a 24-inch pulley at 50 revolutions per minute, and let 3 horse-power be transmitted, then $\frac{33,000 \times 3}{314 \cdot 16} = 312$ lbs., the strain on the pulley due to the force transmitted."—*Fairbairn, Machinery of Transmission*, H. C. Baird, page 99.

"Throughout New England, until within a few years, it was generally thought by engineers and millwrights, that cotton mills, and woolen mills, and all others, requiring a very considerable power, could not be run effectively without large and ponderous

lines of upright, and horizontal shafts of either cast or wrought iron, and heavy trains of cog-wheels of cast iron, or partly of iron and partly of wood.

"And when large leather belts began to be introduced for the main gear of mills, as a substitute for gear-wheels, it was thought by some of our best Engineers to be an experiment, at the least, of very doubtful result, if not altogether impracticable, and indeed at the present time (1837), notwithstanding all the evident advantages of belts over gear-wheels, many still adhere to the old mode of gearing; and this, doubtless, not so much from a want of discernment and sound judgment, as from a lack of opportunity of comparing and testing the advantages of belts, and the disadvantages of gear-wheels; or, perhaps, they may have formed an erroneous opinion of the utility of using belts from the inspection of some mills, that have been belted on a bad principle, or from belts injudiciously managed."

"Having, from a constant practical experience of both modes of gearing mills, for more than ten years, at Lowell, Saco and other places become fully satisfied of the utility of belting mills, instead of running them with gear-wheels, and that they run much lighter, stiller, and with far less friction, and a proportionately less motive power, with belts than with gear-wheels."

"A cotton mill of dimensions adapted to the convenient operation of 4000 spindles, of cotton machinery, including all the preparation for making yarn, and weaving cloth, ordinarily, required four trains of upright shafts, extending through the height of four stories, the trains usually commencing in the basement story."

"To each train of uprights were attached from two to four pairs of heavy gear-wheels, and in addition to these, in many mills all the counter lines of shafts were geared off at right angles with the horizontal main shaft, which required a very large number of gears and shafts. A mill thus geared is a full load for the power of a moderate sized water-wheel without any machinery, and a great proportion of this unnecessary weight and friction may be saved by the judicious use of belts instead of gears. And besides the disadvantages before named, the trains of gear wheels require the constant extra expense of careful attendance, and of oil or some unctuous matter to lubricate and keep them from heating, friction and abrasion. And again, all the gears must be closely boxed in, and

supplied with tight dripping pans, or the mill-grease will be liable to drop into the work and greatly damage, if not entirely ruin it.

"These are serious inconveniences and evils that may be avoided by substituting belts in place of gear-wheels. The first expense, and the constant repairs will be as little with belts as with gear-wheels; and the risk and hindrance that may be caused by belts is far less; for if a main belt breaks, it is the work of a few minutes only to repair it or replace it with a new one, whereas, the breakage of a single gear-wheel may cause the hindrance of a week, and the almost entire loss of the wheel broken, together with a hundred times the labor and expense in exchanging the broken wheel for the new one, that would be caused in repairing or exchanging the belts. And, again, if it should be found desirable at any time to change the velocity of any part of the mill gear, it is much more easily done, and with far less expense, by varying the size of the pulleys and drums than by changing gear-wheels."

"But to gear a mill wholly with belts, and to do it judiciously, and to the best advantage, doubtless requires more nice calculation, careful judgment, and practical experience, than to do it with gear-wheels for many mills have been so belted as to cause more friction, trouble and expense than would be caused or required in the use of gear-wheels." * * * * *

"In laying out the gear of a mill, it is worth much time and pains to arrange the drums and belts in such a manner that, so far as may be practicable, the stress of one belt upon the journals shall be counteracted by that of another belt in an opposite direction, referring to the stress upon the line of main drums, the counter drums being of minor consequence; but where the main power is to be exerted to throw the stress upon one belt into that of another, is economy in the wear of the whole mill gear, as well as in power, both of which are points of great importance to the manufacturer. This point has not always been observed; for it is sometimes more convenient in arranging the gear and machinery of a mill to place the line of main drums upon one side of the mill instead of in the centre. And the effect of this arrangement is to throw the whole stress of the belts upon one side of the journals of the main drum shafts, which ought ever to be avoided."

* * * * * "It is further of great importance that each belt should be of such a length that it will adhere to the drum so much as to prevent it from slipping, and that without the neces-

sity of pulling on the belt so tight as to cramp the drums and wear the bearings. Every belt, to run easy and well, should be so slack, when running, that the slack side should run with a waving, undulating motion, without any tension except on the leading side, and when belts will so run without slipping upon the drums or pulleys they will wear for a great length of time; for although a belt may be heavily loaded, yet, if, at every revolution, it can have an opportunity for relief from its tension so as to contract to its natural texture, it will prevent it from breaking by the stress upon it. But if, otherwise, it be kept strained so tensely as to be constantly strained to its greatest extent on both sides of the drums, it will wear but a short time without cracking at the edges, and will shortly be destroyed."

"Sufficient care is seldom taken to have belts to run free and easy, and it has been one of the greatest errors, more or less prevalent in all cotton or woolen mills, to run the belts so tense as greatly to injure the belts and rapidly increase the wear of the bearings."

"It has been customary in almost all belted mills to affix heavy cast iron, or wooden binders (tighteners) weighted, to the belts which drive the main mill gear, to prevent them from slipping, and it has been generally thought impracticable to keep them from slipping on the pulleys and drums without binders; but this opinion is wholly erroneous, and without any true foundation, if the belts are properly prepared and pulleys and shafts arranged as mentioned above."

"The method taken to make them run light and slack without slipping has been already given, (see Treatment of Leather for Belts,) and the plan succeeded so well that every manufacturer who uses belts ought to know it."—I. H. B. *Frank. Inst. Jour.*, June, 1837, page 451.

(To be continued.)

Combined Rubber and Steel Belts, by Mr. Louis Sterne, England. In these a band of steel is imbedded in layers of rubber which are attached to it during the process of vulcanizing in so firm a manner that it is found impossible to detach them. It is stated that such belts have been found to work well with heavy machinery.

EXPEDITIOUS RAILWAY MAKING.

THE following despatches to the San Francisco (California) *Evening Bulletin* of April 29th, sent by the correspondents at the eastern end of the Central Pacific Railway, within a few mile of its junction with the Union Pacific Railway, explain themselves. It will be seen that upwards of ten miles of line were laid, ready for the passage of trains, in eleven hours.

"Third Despatch—Noon.—A great feat has been accomplished this morning, seven miles of track have been laid by the Central Pacific, and the track layers' party dined in their regular quarters at the end of the new laid track. In one morning 8500 men, 800 horses with teams and all their provender; all the stores of the company and of the Chinese traders, the blacksmith shops, the harness makers' shops, the company's office, the telegraph office, the headquarters of Mr. Stenford, and the abode of Mr. Strobridge and family, and the boarding and sleeping apartments of 500 white men, have moved nine miles as easily as if they had been aboard a large steamship. The dead weight above moved this morning over nine miles of road, seven of which has been built since daylight, includes the ties hauled by teams, without reckoning the rolling stock, fuel or water trains. There are nearly 3000 tons in shop. The camps and commissariat of an army of 10,000 persons have advanced nine miles without the slightest accident into the new country, and no one has suffered the privation of any of the comforts which the best cared for workmen can enjoy in a mountain town. Not only has this been done, but the army was ready in an hour to move again. How many generals ever see moved such an army in a country 130 miles from fresh water? The rate of laying track has been one mile an hour—the first time it has ever been attempted, and it may be the last, for it is not probable that such an army will be organized again.

"Fourth Despatch. End of Central Pacific Track April 28, P. M.—The greatest work in track-laying ever accomplished or conceived by railroad men has been successfully achieved to-day by the Central Pacific Company. Ten miles and 58 feet of railroad (grading excepted) has been made between daylight and sundown. Some two or three miles of this had been hauled out by teams yesterday on the advance, but all the iron rails, fish bars, bolts and spikes were

carried out to-day, and the most part of it was brought a number of miles from the rear, as the station this morning was two miles behind the foremost rails. The ties for over 7 miles had to be hauled by two-horse teams from 5 miles, where they were first laid, to over 12 miles where they were last laid, and this over a rapidly rising grade and mountain road. As there are about 2400 ties to a mile, and they are from 80 to 90 lbs. in weight, it makes 1,244,000 lbs., without the 16,800 ties teamed and laid. This only represents part of the work done by teams, as all the blacksmith, wheelwright and other workshops went by the wagon road. One length of such camp wagons by count numbered 25, and, spun out in a thin line, looked like one of the large emigrant trains of former days. The iron moved by the construction train was 1000 tons, and the whole of that has been laid, spiked, fished and bolted in 11 working hours, and the road to the end of the track, though needing a little revision in places, is fit for travel and in fair condition. The difficulty of doing this work was increased by the necessity of carrying a large water-tank car with every one of the six engines employed. It was still increased by the number of curves, which required the bending of the rails in many places for several lengths, which had to be done on the ground as the curves right or left required. The feat of laying over 7 miles in one stretch was once done by the Union Pacific, but they worked from four in the morning until after midnight. Therefore it could not be considered an honest day's work. The Central men would have laid 14 miles, and finished their portion of the great Pacific Road to-night, had the grading been completed. As it was, the men were anxious to lay 12 miles, but there were not ties enough within 50 miles of the spot."

ON NEW EXPLOSIVE POWDERS.

BY M. DESIGNOLLE.

(ABSTRACT.)

MANY improvements having lately been made in the art of war, and particularly in the adoption of breech-loading arms, the want has been felt of new powders to meet the requirements of the present artillery. This want has been supplied by M. Designolle, who

has invented a new system of powders of which carbazotate or picrate of potash is the base. These powders are of four kinds—viz., a musket powder, gunpowder for short bore cannons, slow gunpowder for cannons with long bores, and an explosive powder for torpedoes and projectiles destined for the undermining of fortifications. The principal advantages of these new powders are the following:—Increase of ballistic power without increase of explosive power; the base remaining the same, possibility of regulating and varying the effects between the limits of one to ten; also of regulating, at will, the rapidity of combustion of this powder, and of increasing the ballistic power without changing the mode of manufacture. Other advantages are—regularity in the manner of action; suppression of sulphur, and consequently of the vapors of sulphide of potassium and sulphuretted hydrogen; absence of action on metals and almost entire suppression of smoke. Into the explosive powders only two components enter—picrate of potash and nitrate of potash; the musket and gunpowders contain carbon in addition to the above-named ingredients. To prepare these powders, the ingredients are beaten from three to six hours with a proportion of water varying from 6 to 14 per cent., according to the nature of the mixture; the powder is condensed by means of the hydraulic press, with a pressure of from 30,000 to 100,000 kilos., graining of the powder, and pressing and drying it according to the methods employed for the black powder. In order to increase the ballistic power, the relative proportion of picrate of potash in the mixture must be increased. For musket powder it has been proved that not more than 20 per cent. of picrate of potash is required, while for gunpowders its proportion varies from 8 to 15 per cent. This component (picrate of potash) is of a beautiful golden yellow color, and crystallizes in prismatic needles possessing a brilliant reflection; it is insoluble in alcohol, but soluble in about 260 parts of water at 15 or 14 parts of boiling water. Heated with care it becomes orange red at a temperature of 300° , but, on cooling, it assumes its original color. Heated to 310° , it detonates with violence. The researches of M. John Casthellaz on the action of nitric acid on phenic acid improved the method of manufacturing picric acid, and produced chemically pure picrate of potash at such a reasonable price that the new powders are not more expensive than ordinary black powder.

MM. Designolle and Casthellaz give the following proportions for preparing deflagrating mixtures with colored flames :

Golden fire	{	Picrate of ammonia. 50
		Picrate of iron..... 50
Green fire.....	{	Picrate of ammonia. 48
		Nitrate of barytes.... 52
Red fire.....	{	Picrate of ammonia. 54
		Nitrate of strontian. 46

—*Bulletin de la Société d'Encouragement pour l'Industrie Nationale.*

A STEAM PLOW.

THE steam plow and accompanying apparatus, imported by Col. Wm. E. Patterson from Leeds, England, was put in operation on Tuesday last, on the recent purchase of that gentleman at Atsion, New Jersey.

Colonel Patterson's large tract of land in that locality is to be devoted to the culture of sugar beet. As the soil is a sandy loam, closely akin to that in which the French have been so successful in sugar beet culture, Colonel Patterson sees no reason why a profit cannot be realized in this country in the same direction.

The test of this steam plow was made in the presence of a considerable number of people, including General Capron, of the United States Agricultural Bureau at Washington. This gentleman, having beaten his sword into a ploughshare, has from the first taken active interest in the subject of relieving horses from this arduous and exhausting labor. Through his intervention the apparatus, which cost \$13,000, was admitted free of duty, and at its successful operation on Tuesday no one evinced a higher degree of satisfaction.

The machinery is by no means complicated. At opposite sides of the space to be plowed are two steam engines upon wheels. On the trial on Tuesday they stood three hundred yards apart. The plow has six shares. It is a distinct piece of mechanism, and is fastened to a steel wire cable extending between the two locomotives across the ground to be turned over. It is literally a shuttle cock between two steam battledores. It moves at the speed of a hundred yards a minute, turning six furrows a foot each in width, and eight inches in depth. Its average work, therefore, is twenty acres per day. The locomotives are snug machines, capable of

being applied to many useful purposes independent of duty as steam plowers.

A man rides on the plow as it crosses the soil. General Capron essayed a trip or two, guiding the machine like an expert upon a velocipede. One of the experts who mounted it just after him had less good fortune. One of the diggers struck a buried boulder. When an irresistible body in motion strikes against an immovable one a rumpus must be the result. In this case the man upon the machine was slung high into the air. The concussion broke off two of the teeth of the digger, but as a new one immediately replaced it, the accident was a matter of little consequence.

Of this large track of ground much is virgin soil. The trunks of many cedars, showing slight evidences of decay, were brought to light by the steam plowshares. These were crunched up by them as if they were mere touchwood. The soil above them is largely made up of decayed vegetable matter, and in the opinion of all who were present, the sugar beet will produce in it enormous crops. A digging machine accompanies the plow, intended for use in soils where roots and stones are obstacles to the course of the plowshare. This is a wonderful apparatus. It so triturates the stiffest soil that a yankee might put it into bladders and vend it as a substitute for snuff.

The trial was witnessed, among others, by General Fitz John Porter, Wm. B. Tatham, General Robert Patterson and family, Judge Carpenter, of New Jersey; Mr. Landreth, of Philadelphia; T. C. Peters, of New York; B. M. Rhodes, of Baltimore; Mr. Harry McCall, and a strong delegation of gentlemen from various parts of the surrounding country.

The machinery is the work of Towles & Co., of Leeds, England. To work it costs extremely little. Anything answers as fuel, and at the rate of twenty acres a day a large estate is soon put under cultivation. The locomotives are then ready for ordinary duty as steam engines, either to grind or thresh, sew or mash.

Improvement in the Holtz Machine.—Mr. Joseph Cresson, of this city, has found that the pieces of paper usually attached as inductors, may be replaced with great advantage by figures of like shape painted on the glass with white lead. This never curls up at the edge and is more easily insulated.

THE TOWER SUBWAY.

AMONST the many great improvements now going on in London to relieve the over-crowded state of traffic, and for opening up new means of communication, the Tower Subway is one which deserves especial notice, as forming an easy and safe connection between the two densely-populated districts situated north and south of the Thames, between London Bridge and the Thames Tunnel. This work is now in course of construction under the bed of the river, from Tower Hill to Tooley Street, and consists of a tunnel less than a quarter of a mile in length, access being gained to it by a shaft at each end. The depth of these shafts will be 52 feet and 60 feet respectively, in which it is proposed to have plumb lifts for the transit of passengers, parcels, etc., to and from the subway, through which an omnibus running on steel rails is propelled, both being worked by steam power. In driving the subway, which will be about 22 feet below the bed of the river, a wrought iron shield will be employed overlapping the tunnel, provided with doors in the front, through which workmen can drive the heading, but which can be immediately closed on any appearance of water, and so render all water-tight; this shield will be propelled by powerful screws, and as it progresses, the tunnel segments will be inserted. The whole of the work is under the superintendence of Mr. Peter W. Barlow, Jr., C. E., the engineer; the contractor being Mr. J. H. Greathead, under whose superintendence the shafts are now being sunk by Mr. Thomas Tilley, of 2 Bond Court, Walbrook, London, the well known artesian well engineer. The castings for these shafts and the tunnel, which are all made in segmental rings firmly bolted together, as also the manufacture of the shield, are entrusted to the firm of Messrs. Bells, Goodman & Co., of the Walker Engine Works and Foundry, Newcastle-upon-Tyne, and 25 Walbrook, London. The Tower Subway was commenced on the 16th of last February, and as the shaft for the Middlesex side is already sunk to the depth of 60 feet, and the remainder of the work well advanced, we are informed that it is expected to be opened to the public before the commencement of the year 1870.—*Mec. Mag.*

Mechanics, Physics, and Chemistry.

ON THE BLUE COLOR OF THE SKY, THE POLARIZATION OF SKY-LIGHT, AND POLARIZATION OF LIGHT BY CLOUDY MATTER GENERALLY.

BY JOHN TYNDALL, L.L.D., F.R.S.

SINCE the communication of my brief abstract "On a new Series of Chemical Reactions produced by Light," the experiments upon this subject have been continued, and the number of the substances thus acted on considerably augmented. New relations have also been established between *mixed vapors* when subjected to the action of light.

I now beg to draw the attention of the Royal Society to two questions glanced at incidentally in the abstract referred to—the blue color of the sky, and the polarization of skylight. Reserving the historic treatment of the subject for a more fitting occasion, I would merely mention now that these questions constitute, in the opinion of our most eminent authorities, the two great standing enigmas of meteorology. Indeed it was the interest manifested in them by Sir John Herschel, in a letter of singular speculative power, that caused me to enter upon the consideration of these questions so soon.

The apparatus with which I work consists, as already stated to the Society, of a glass tube about a yard in length, and from two and a half to three inches internal diameter. The vapor to be examined is introduced into this tube in the manner described in my last abstract, and upon it the condensed beam of the electric lamp is permitted to act until the neutrality or the activity of the substance has been declared.

It has hitherto been my aim to render the chemical action of light upon vapors *visible*. For this purpose substances have been chosen, one at least of whose products of decomposition under light shall have a boiling-point so high that as soon as the substance is formed it shall be *precipitated*. By graduating the quantity of the vapor, this precipitation may be rendered of any degree of fineness, forming particles distinguishable by the naked eye, or particles which

are probably far beyond the reach of our highest microscopic powers.

I have no reason to doubt that particles may be thus obtained whose diameters constitute but a very small fraction of the length of a wave of violet light.

In all cases when the vapors of the liquids employed are sufficiently attenuated, no matter what the liquid may be, the visible action commences with the formation of a *blue cloud*. I would guard myself at the outset against all misconception as to the use of this term. The blue cloud to which I here refer is totally invisible in ordinary daylight. To be seen, it requires to be surrounded by darkness, *it only* being illuminated by a powerful beam of light. This blue cloud differs in many important particulars from the finest ordinary clouds, and might justly have assigned to it an intermediate position between these clouds and true cloudless vapor.

With this explanation, the term "cloud," or "incipient cloud," as I propose to employ it, cannot, I think, be misunderstood.

I had been endeavoring to decompose carbonic acid gas by light. A faint bluish cloud, due it may be, or it may not be, to the residue of some vapor previously employed, was formed in the experimental tube. On looking across this cloud through a Nicol's prism, the line of vision being horizontal, it was found that when the short diagonal of the prism was vertical, the quantity of light reaching the eye was greater than when the long diagonal was vertical.

When a plate of tourmaline was held between the eye and the bluish cloud, the quantity of light reaching the eye when the axis of the prism was perpendicular to the axis of the illuminating beam, was greater than when the axes of the crystal and of the beam were parallel to each other.

This was the result all round the experimental tube. Causing the crystal of tourmaline to revolve round the tube, with its axis perpendicular to the illuminating beam, the quantity of light that reached the eye was in all its positions a maximum. When the crystallographic axis was parallel to the axis of the beam, the quantity of light transmitted by the crystal was a minimum.

From the illuminated bluish cloud, therefore, polarized light was discharged, the direction of maximum polarization being at right angles to the illuminating beam; the *plane of vibration* of the

polarized light, moreover, was that to which the beam was perpendicular.*

Thin plates of selenite or of quartz, placed between the Nicol and the bluish cloud, displayed the colors of polarized light, these colors being most vivid when the line of vision was at right angles to the experimental tube. The plate of selenite usually employed was a circle, thinnest at the centre, and augmenting uniformly in thickness from the centre outwards. When placed in its proper position between the Nicol and the cloud, it exhibited a system of splendidly colored rings.

The cloud here referred to was the first operated upon in the manner described. It may, however, be greatly improved upon by the choice of proper substances, and by the application in proper quantities of the substances chosen. Benzol, bisulphide of carbon, nitrite of amyl, nitrite of butyl, iodide of allyl, iodide of isopropyl, and many other substances may be employed. I will take the nitrite of butyl as illustrative of the means adopted to secure the best result with reference to the present question.

And here it may be mentioned that a vapor, which when alone, or mixed with air in the experimental tube, resists the action of light, or shows but a feeble result of this action, may, by placing it in proximity with another gas or vapor, be caused to exhibit under light vigorous, if not violent, action. The case is similar to that of carbonic acid gas, which diffused in the atmosphere resists the decomposing action of solar light, but when placed in contiguity with the chlorophyl in the leaves of plants, has its molecules shaken asunder.

Dry air was permitted to bubble through the liquid nitrite of butyl until the experimental tube, which had been previously exhausted, was filled with the mixed air and vapor. The visible action of light upon the mixture after fifteen minutes' exposure was slight. The tube was afterwards filled with half an atmosphere of the mixed air and vapor, and another half atmosphere of air which had been permitted to bubble through fresh commercial hydrochloric acid. On sending the beam through this mixture, the action paused barely sufficiently long to show that at the moment of commencement the

* I assume here that the plane of vibration is perpendicular to the plane of polarization. This is still an undecided point; but the probabilities are so much in its favor, and it is in my opinion so much preferable to have a physical image on which the mind can rest, that I do not hesitate to employ the phraseology in the text. Even should the assumption prove to be incorrect, no harm will be done by the provisional use of it.

tube was optically empty. But the pause amounted only to a small fraction of a second, a dense cloud being immediately precipitated upon the beam which traversed the mixture.

This cloud began *blue*, but the advance to whiteness was so rapid as almost to justify the application of the term instantaneous. The dense cloud, looked at perpendicularly to its axis, showed scarcely any signs of polarization. Looked at obliquely, the polarization was strong.

The experimental tube being again cleansed and exhausted, the mixed air and nitrite of butyl vapor was permitted to enter it until the associated mercury column was depressed one-tenth of an inch. In other words, the air and vapor, united, exercised a pressure not exceeding $\frac{1}{10}$ th of an atmosphere. Air passed through a solution of hydrochloric acid was then added till the mercury column was depressed three inches. The condensed beam of the electric light passed for some time in darkness through this mixture. There was absolutely nothing within the tube competent to scatter the light. Soon, however, a superbly blue cloud was formed along the track of the beam, and it continued blue sufficiently long to permit of its thorough examination. The light discharged from the cloud at right angles to its own length was *perfectly* polarized. By degrees the cloud became of whitish blue, and for a time the selenite colors obtained by looking at it normally were exceedingly brilliant. The direction of maximum polarization was distinctly at right angles to the illuminating beam. This continued to be the case so long as the cloud maintained a decided blue color, and even for some time after the pure blue had changed to whitish blue. But as the light continued to act the cloud became coarser and whiter, particularly at its centre, where it at length ceased to discharge polarized light in the direction of the perpendicular, while it continued to do so at both its ends.

But the cloud which had thus ceased to polarize the light emitted normally, showed vivid selenite colors when looked at *obliquely*. The direction of maximum polarization changed with the texture of the cloud. This point shall receive further illustration subsequently.

A blue, equally rich and more durable, was obtained by employing the nitrite of butyl vapor in a still more attenuated condition. Now the instance here cited is *representative*. In all cases, and with all substances, the cloud formed at the commencement, when the precipitated particles are sufficiently fine, is *blue*, and it can be made

to display a color rivalling that of the purest Italian sky. In all cases, moreover, this fine blue cloud polarizes *perfectly* the beam which illuminates it, the direction of polarization enclosing an angle of 90° with the axis of the illuminating beam.

It is exceedingly interesting to observe both the perfection and the decay of this polarization. For ten or fifteen minutes after its first appearance, the light from a vividly illuminated incipient cloud, looked at horizontally, is absolutely quenched by a Nicol's prism with its longer diagonal vertical. But as the sky-blue is gradually rendered impure by the introduction of particles of too large a size, in other words, as real clouds begin to be formed, the polarization begins to deteriorate, a portion of the light passing through the prism in all its positions. It is worthy of note that for some time after the cessation of perfect polarization the *residual* light which passes, when the Nicol is in its position of minimum transmission, is of a gorgeous blue, the whiter light of the cloud being extinguished.* When the cloud texture has become sufficiently coarse to approximate to that of ordinary clouds, the rotation of the Nicol ceases to have any sensible effect on the quality of the light discharged normally.

The perfection of the polarization in a direction perpendicular to the illuminating beam is also illustrated by the following experiment. A Nicol's prism large enough to embrace the entire beam of the electric lamp was placed between the lamp and the experimental tube. A few bubbles of air, carried through the liquid nitrite of butyl, were introduced into the tube, and they were followed by about three inches (measured by the mercurial gauge) of air which had been passed through aqueous hydrochloric acid. Sending the polarized beam through the tube, I placed myself in front of it, my eye being on a level with its axis, my assistant Mr. Cottrell occupying a similar position behind the tube. The short diagonal of the large Nicol was in the first instance vertical, the plane of vibration of the emergent beam being therefore also vertical. As the light continued to act, a superb blue cloud, visible to both my assistant and myself, was slowly formed. But this cloud, so deep and rich when looked at from the positions mentioned, *utterly disappeared when looked at vertically downwards, or vertically upwards*. Reflection from the cloud was not possible in these

* This seems to prove that particles too large to polarize the blue, polarize perfectly light of lower refrangibility.

directions. When the large Nicol was slowly turned round its axis, the eye of the observer being on the level of the beam, and the line of vision perpendicular to it, entire extinction of the light emitted horizontally occurred where the longer diagonal of the large Nicol was vertical. But now a vivid blue cloud was seen when looked at downwards or upwards. This truly fine experiment was first definitely suggested by a remark addressed to me in a letter by Prof. Stokes.

Now, as regards the polarization of skylight, the greatest stumbling block has hitherto been that, in accordance with the law of Brewster, which makes the index of refraction the tangent of the polarizing angle, the reflection which produces perfect polarization would require to be made *in air upon air* and indeed this led many of our most eminent men, Brewster himself among the number, to entertain the idea of *molecular reflection*. I have, however, operated upon substances of widely different refractive indices, and therefore of very different polarizing angles as ordinarily defined, but the polarization of the beam by the incipient cloud has thus far proved itself to be *absolutely independent of the polarizing angle*. The law of Brewster does not apply to matter in this condition, and it rests with the undulatory theory to explain why. Whenever the precipitated particles are sufficiently fine, no matter what the substance forming the particles may be, the direction of maximum polarization is at right angles to the illuminating beam, the polarizing angle for matter in this condition being invariably 45° . This I consider to be a point of capital importance with reference to the present question.*

That *water-particles*, if they could be obtained in this exceedingly fine state of division, would produce the same effects, does not admit of reasonable doubt. And that they must exist in this condition in the higher regions of the atmosphere is, I think, certain. At all

* The difficulty referred to above is thus expressed by Sir John Herschel:—
 “The cause of the polarization is evidently a reflection of the sun’s light upon *something*. The question is on what? Were the angle of maximum polarization 76° , we should look to water or ice as the reflecting body, however inconceivable the existence in a cloudless atmosphere, and a hot summer’s day of unevaporated molecules (particles?) of water. But though we were once of this opinion, careful observation has satisfied us that 90° , or thereabouts, is a correct angle, and that therefore whatever be the body on which the light has been reflected, *if polarized by a single reflection*, the polarizing angle must be 45° , and the index of refraction, which is the tangent of that angle, unity; in other words, the reflection would require to be made *in air upon air*!” (‘Meteorology,’ par. 233.)

events, no other assumption than this is necessary to completely account for the firmamental blue and the polarization of the sky.*

Suppose our atmosphere surrounded by an envelope impervious to light, but with an aperture on the sunward side through which a parallel beam of solar light could enter and traverse the atmosphere. Surrounded on all sides by air not directly illuminated, the track of such a beam through the air would resemble that of the parallel beam of the electric lamp through an incipient cloud. The sunbeam would be *blue*, and it would discharge laterally light in precisely the same condition as that discharged by the incipient cloud. In fact the azure revealed by such a beam would be to all intents and purposes that which I have called a "blue cloud."†

(To be continued.)

THE GREAT INDUCTION COIL.

ONE of the greatest scientific wonders, even in this wonder-producing age, is unquestionably the great induction coil—or inducturium, as the German physicists term it—at the Polytechnic Institution. It is an instrument of remarkable power and capacity, and possesses the highest scientific interest.

The machine consists of an ebonite barrel, 9 feet 10 inches in length, supported at each end on two ebonite pillars. The barrel was made at the Silvertown Works, and is the largest ever turned out there. It contains the compound coil, and of itself weighs 477 pounds, the whole machine weighing 15 cwt.

* Any particles, if small enough, will produce both the color and the polarization of the sky. But is the existence of small water-particles on a hot summer's day in the *higher regions of our atmosphere* inconceivable? It is to be remembered that the oxygen and nitrogen of the air behave as a vacuum to radiant heat, the exceedingly attenuated vapor of the higher atmosphere being therefore in practical contact with the cold of space.

† The opinion of Sir John Herschel, connecting the polarization and the blue color of the sky is verified by the foregoing results. "The more the subject (the polarization of skylight) is considered," writes the eminent philosopher, "the more it will be found beset with difficulties, and its explanation when arrived at will probably be found to carry with it that of the blue color of the sky itself, and of the great quantity of light it actually does send down to us." "We may observe, too," he adds, "that it is only where the purity of the sky is most absolute that the polarization is developed in its highest degree, and that where there is the slightest perceptible tendency to cirrus it is materially impaired." This applies word for word to the "incipient clouds."

The primary wire is of copper of the highest conductivity 0.0925 inches diameter (B. W. G. No. 13), and 3,770 yards in length; the number of revolutions of the primary wire round the soft iron core is 6,000, its arrangement being three, six, and twelve strands. The total resistance of the primary coil is 2.201400 British Association units; and the resistances of the primary conductors are respectively, for the three strands, 0.733800; for the six, 0.366945; for the twelve, 0.1834725 B. A. units. The soft iron core is composed of straight wires of very soft iron, each wire being 5 feet in length, and 0.0625 inches in diameter. The diameter of the bundle of core wires is four inches, and their weight 123 pounds. The secondary wire is 150 miles in length, 0.015 inch diameter, (B. W. G. No. 29), and is covered with silk. The total weight of the wire is 606 pounds, and its electrical resistance 33,560 B. A. units. The secondary coil is 4 feet 2 inches long, and the insulation is calculated for safety at 95 per cent. beyond absolute requirement. The secondary wire is insulated from the primary by an ebonite tube 8 feet in length, and $\frac{1}{2}$ inch in thickness. The condenser is made of sheets of varnished paper and tinfoil, arranged in six parts, each containing 125 feet of surface, or a total of 750 feet.

The machine was originally tried with a contact breaker detached from the great coil, and having an independent electro-magnet; this worked well up to ten Bunsen cells with the great inductorium, but when the battery was increased to thirty or forty cells it became unmanageable. A Ruhmkorff break, with mercury and alcohol above it, was substituted, which saved the points, but the spirit was now and then violently ejected and set on fire. Professor Pepper then proposed a modification, which has proved successful, remaining in perfect working order during a series of experiments extending over eight hours. The commutator regulating the admission of the battery current is provided with a locking apparatus, and the whole coil is most carefully and effectually insulated from the floor and surrounding apparatus, as are also the separate portions of the apparatus from each other. The battery power is at present supplied by forty Bunsen cells, each containing a pint of nitric acid. It is, however, intended to substitute for this, a Grove's battery of the largest size ever made, and which is in course of construction. It will consist of pipe-clay cells 2 feet square upon the sides, and 3 inches wide, with walls an eighth of an inch thick.

In working the great induction coil, the sparks obtained from it

with five Bunsen cells, are 12 inches in length; ten cells give sparks 14 inches in length; fifteen cells give $17\frac{1}{2}$ -inch sparks; twenty cells give 21-inch sparks; twenty-five cells give 23-inch sparks; thirty cells give $23\frac{1}{2}$ -inch sparks; thirty-five cells give 26-inch sparks; forty cells give $27\frac{1}{2}$ -inch sparks; and with fifty cells, sparks from 28-inch to 29-inch in length were obtained. After eight hours working, the coil gave, with fifty cells, a spark $25\frac{1}{2}$ inches in length. It was also found that of the proportions of the condenser used, one-half gave the longest spark. The spark is not such as is generally produced under similar circumstances, but is a thick wire of light, surrounded by a wide waving flame 2 inches or three inches thick, and which can be blown aside from the spark. The spectroscope gives a perfectly continuous spectrum, like the light of day, only that it is barred with the bright lines of the substances in combustion. The flame of the spark, with a very slight blast of air, rises to at least 12 inches in height when it is passing about the same distance horizontally.

Besides the gigantic Grove's battery, there is also a Leyden battery in course of construction, the present one being inadequate to represent the full power of the coil. The first part of this battery, consisting of 250 square feet of coated glass, is now nearly completed. There is also a very large and elegant arrangement of Gassiot's cascade in course of construction, which is also to work with the great induction machine, and which will embody several important improvements that have been suggested by Mr. Gassiot. The most recent experiments with the coil have shown that as yet no limit as to the quantity of effects can be established, and it is exceedingly probable that by a very few minutes' working, the large coil would charge at least 1,000 Leyden jars of very large size.—*Mec. Mag.*

SPECTROSCOPIC OBSERVATIONS OF THE SUN.

BY J. NORMAN LOCKYER.

IN a former paper the author stated that Dr. Frankland and himself had searched without success for the known third line of hydrogen in the spectrum of the chromosphere. He has now discovered that the position of the third line is at 2796 Kirchhoff's scale. The author assumes that the darkening of the limb is due to the general absorption of the chromosphere, and therefore it follows:

1. That the additional selective absorption near the limb is extremely probable.

2. That the hydrogen Fraunhofer lines indicating the absorption of the outer shell of the chromosphere will vary somewhat in thickness: this he found to be the case to a certain extent.

3. That it is not probable that the prominences will be visible on the sun's disc.

On the 20th of February a spot was observed in which the *general* absorption was so great that the several lines could only be distinguished with difficulty, except in the very brightest region, which is ascribed to the greater length of the absorbing medium in the spot itself in the line of sight when the spot is observed near the limit instead of the centre of the disc.

Mr. Lockyer has succeeded in adding magnesium and barium to the material (sodium) to which he referred in paper No. 1 (published in 1866). He no longer regards a spot simply as a cavity, but as a place in which principally the vapors of sodium, barium and magnesium occupy a lower position than they do ordinarily in the photosphere. It therefore follows:

1. The lines of sodium, magnesium and barium, when observed in a spot, are thicker than their usual Fraunhofer lines.

2. The lines of sodium, magnesium and barium, when observed in the chromosphere, are thinner than their usual Fraunhofer lines.

These facts give additional evidence that a spot is the seat of a downrush—a downrush to a region, as we now know, where the selective absorption of the upper strata is different from what it would be, and indeed is elsewhere at a higher level.

The author thinks there are two causes for the darkening of a spot, viz:

1. The general absorption of the chromosphere thicker here than elsewhere, as the spot is a cavity.

2. The greater selective absorption of the lower sodium, barium, magnesium stratum, as the surface of its last layer is below the ordinary level.

Mr. Lockyer is waiting to make observations with the large Stenheil spectroscope to finally test the accuracy of the valuable suggestion of Messrs. De la Rue, Stewart and Loewy, in their "Researches on Solar Physics," that if the photosphere of the sun be the plane of condensation of gaseous matter, the plane may be found to be subject to periodical elevations and depressions, and that at

the epoch of minimum sun-spot frequency the plane might be uplifted very high in the solar atmosphere, so that there is comparatively little cold absorbing atmosphere above it, and therefore great difficulty in forming a spot.

With a rapidly oscillating slit the author was not satisfied with his results, but on hearing that Mr. Huggins had succeeded in seeing the form of the solar protuberances, by using absorbing media and a wide slit, he was led to try the wide slit without the absorptive media, and in the following words he describes the results:—"The solar and atmospheric spectra being hidden, and the wide image of the slit alone being visible, the telescope or slit is moved slowly, and the strange shadow-forms flit past. Here one is reminded by the fleecy, infinitely delicate cloud-films of an English hedge-row with luxuriant elms; here of a densely intertwined tropical forest, the intimately interwoven branches threading in all directions, the prominences generally expanding as they mount upwards, and changing slowly, almost, indeed, imperceptibly. By this method the smallest details of the prominences and of the chromosphere itself are rendered perfectly visible and easy of observation."

In an addendum dated March 17th, the author states that more favorable weather had enabled him to continue his researches in reference to his method for viewing the prominences and to view the injection of sodium, magnesium, &c., into the chromosphere. He thinks that in time it will be possible to see the prominences as they really are seen in an eclipse by constructing a rapidly revolving wheel with red, green and violet glass of the required absorptions, in which the percentages of light of each color may be regulated. On the 14th of March, with a tangential slit, a fine dense prominence near the sun's equator on the eastern limb was observed.—*Chem. News.*

ON THE LIGHTNING SPECTRUM.

BY LIEUT. JOHN HERSCHEL, R. E.

I have had two or three opportunities of seeing this spectrum to advantage of late. The storms at the period of setting in of the south-west monsoon here are very frequent, and supply for a time almost incessant flashes, many of which are of course very brilliant. The first time I examined the light in the spectroscope I

had no idea of measuring, but was content to realize the principal facts of a continuous spectrum crossed by bright lines; but subsequently I made several attempts (with some success) to obtain measures. That I was unable to do more in this line is due partly to the difficulty of utilizing the short-lived appearance, partly to that fascination of waiting for "one more" bright flash to verify the intersection, which can only be thoroughly appreciated by the aid of a similar experience.

The principal features of the spectrum are a more or less bright continuous spectrum crossed by numerous bright lines, so numerous indeed as to perplex one as to their identity. This perplexity is increased by the constantly changing appearance due to a variable illuminating power. This variable character of the appearances is unquestionably the peculiar feature of the spectrum. It is not that the whole spectrum varies in brightness in the same degree, but that the *relative* intensities are variable, not only among the various lines, but between these and the continuous spectrum. The latter is sometimes very brilliant; and when that is the case, the red portion is very striking, though in general the spectrum seems to end abruptly at $D + 0.34$ ($E = D + 1.38$, Kirchhoff's $120.7 = D + 0.55$.)

There is one principal line which I found equal to $D + 2.20$ as the result of five independent measures. The probable error of this value is about ± 0.02 . The general mean of all my measures of the principal *nebular* line (obtained from twelve different nebulae) is 2.18 , with a probable error of about ± 0.02 . I have therefore very little doubt that these are the same, viz.: the nitrogen line identified in the case of nebulae of Mr. Huggins. This line in the lightning spectrum is narrow and sharply defined, and is conspicuously the brightest, except as noted below.

The next in prominence is situated about $D + 3.58$ ($F = D + 2.73$, Kirchhoff's $232.5 = D + 3.50$). It is broader and less vivid, and not so well defined at the edges.

There are several other conspicuous lines, but none comparable to the first. I noticed a sharp line in the red, but did not get a measure.

I said that at $D + 0.34$ the continuous spectrum ends abruptly. A faint continuation is, however, seen frequently in bright flashes, very bright ones bringing out a brilliant red end crossed by a bright line.

The whole of the ordinary spectrum *seems* green and blue, or rather greenish blue; but as the usual prismatic order of colors is recognizable in bright flashes, it is to be inferred that the region from E to F is so much brighter as to give the character in question. What strikes one most, however, is the varying relative brightness of the continuous and linear spectra; sometimes the lines are scarcely seen, and sometimes very little else is seen. This may be nothing more than an illusion; but in the absence of any certainty that it is so, the impression left on the mind is worth recording.

The difficulty of discriminating between the many less prominent lines is immensely increased by the momentary character of the phenomenon. Before the mind has selected an individual, the feeble impression on the retina has vanished; and before another flash succeeds, the memory of the half-formed choice has vanished with it, and there is nothing on which to found a selection. Otherwise it would be easy enough to measure many more lines.

ON SOME OPTICAL PHENOMENA OF OPALS.

BY WILLIAM CROOKES, F.R.S., &c.

BY means of the spectrum microscope (described Vol. LIV., page 335 of this *Journal*), some curious optical phenomena of opals have been observed.

If an opal which emits a fine broad crimson light is held in front of the slit of a spectroscop, or spectrum microscope, at the proper angle, the light is generally seen to be purely homogeneous, and all that is visible is a brilliant luminous line, varying somewhat in width, and more or less irregular in outline, but very sharp, and shining brightly on a perfectly black ground. If a source of light is now moved so as to shine into the spectrum apparatus through the opal, the above appearance is reversed, and we have a luminous spectrum with a jet-black absorption band in the red, identical in position, form of outline and sharpness, with the luminous line previously observed.

From these and other experiments, it has been found that those parts of the opal which emit red, yellow, green or blue light, are opaque to light of the same refrangibility which they emit. This is doubtless a general law, following of necessity the mode of production of the flashes of color.

From the description of the absorption phenomena of a series of opals, the following are selected as the most striking:—

No. 1 shows a single black band in the red. When properly in focus, this has a spiral structure. Examined with both eyes, it appears in decided relief, and the arrangement of light and shade is such as to produce a resemblance to a twisted column.

No. 2 gives an irregular line in the orange. Viewed binocularly, this exhibits the spiral structure in a marked manner, the different depths and distances standing well out; upon turning the milled head of the stage adjustment so as to carry the opal slowly from left to right, the line is seen to revolve and roll over, altering its shape and its position in the spectrum. It is not easy to retain the conviction that one is looking merely at an absorption band in the spectrum, and not at a solid body possessing dimensions and in actual motion.

No. 9 shows a very sharp and black band stretching diagonally across the green, touching the blue at the top, and the yellow at the bottom.

No. 12 gives a narrow, straight, and sharply-cut line in the green; this might easily be mistaken for an absorption band caused by an unknown chemical element.

Other opals show an absorption band traveling along the spectrum, almost from one end to the other, as the opal is moved sideways. All these black bands can be reversed, and changed into luminous bands, by examining the opal with reflected light.

ON THE LOWERING OF TEMPERATURE DUE TO THE SOLUTION OF SALTS IN WATER.

THE decrease of temperature will be the greater the larger the quantity of any salt which water takes up at a certain given temperature. Since, however, water at a certain temperature only dissolves a definite quantity of any salt, the maximum decrease of temperature will be about that at which, under given circumstances, a fully saturated solution is produced. When, therefore, the salt and the water are applied in the proportion where from a saturated solution results, a long period of time elapses before the last portions of the salt are entirely dissolved, and the effect of the warm ambient air to some extent vitiates the proper results of the experiments; the saturated solution should therefore be obtained as

rapidly as possible. The experiments were conducted in the following manner:—The finely-powdered salt and the requisite quantities of water were, previous to the making of the experiments, each put in separate beakers made of very thin glass, and placed, for from 12 to 18 hours, in a room wherein the temperature could be kept as nearly as possible constant; in consequence of this the beakers and contents attained the same temperature throughout. The mixing was effected by pouring the water on to the salt, and stirring up with a very delicate and highly sensitive thermometer; the maximum decrease of temperature took place within a minute after the mixing of the salt and water was made. The results of the experiments are exhibited in the following tabulated form, recording the average of a series of several experiments with one and the same substance, which were concordant within 0.2° :—

	Soluble in 100 parts of water.	Mixed with 100 parts of water.	The temperature falls		Number of Degrees.
			From $^{\circ}\text{C}.$	To $^{\circ}\text{C}.$	$^{\circ}\text{C}.$
Crystallized alum.....	10.0	14	+10.8	+ 9.4	1.4
Chloride of sodium.....	85.8	86	12.6	+10.1	2.5
Sulphate of potassa.....	9.9	12	14.7	+11.7	3.0
Crystallized phosphate of soda.....	9.0	14	10.8	+ 7.1	3.7
Sulphate of ammonia.....	72.8	75	13.2	+ 6.8	6.4
Sulphate of soda (crystals).....	16.8	20	12.5	+ 5.7	6.8
Sulphate of magnesia (crystals).....	80.0	85	11.1	+ 3.1	8.0
Carbonate of soda (crystals).....	30.0	40	10.7	+ 1.6	9.1
Nitrate of potassa.....	15.5	16	13.2	+ 3.0	10.2
Chloride of potassium.....	28.6	30	13.2	+ 0.6	12.6
Carbonate of ammonia.....	25.0	30	15.3	+ 3.2	12.1
Acetate of soda (crystals).....	80.0	85	10.7	— 4.7	15.4
Chloride of ammonium.....	28.2	30	13.3	— 5.1	18.4
Nitrate of soda.....	69.0	75	13.2	— 5.8	18.5
Hyposulphite of soda (crystals).....	98.0	110	10.7	— 8.0	18.7
Iodide of potassium.....	120.0	140	10.8	—11.7	22.5
Chloride of calcium (crystallized)....	200.0	250	10.8	—12.4	23.2
Nitrate of ammonia.....	55.0	60	13.6	—13.6	27.2
Sulphocyanide of ammonium.....	105.0	133	13.2	—13.0	31.2
Sulphocyanide of potassium.....	180.0	150	10.8	—23.7	34.5

The quantity of water applied varied between 250 and 500 grammes, and the quantity of salt used corresponded therewith. The decrease of temperature obtainable in this manner can never fall below the freezing point of the saline solution in question, but can very nearly reach that. The sulphocyanide of potassium is the best salt to be adopted for the artificial production of ice; when 500 grammes of this salt are dissolved in 400 cubic centimetres of water, and the mixture stirred with a test-tube filled with water, the latter will be frozen in from two to three minutes. The degree of solubility of the salts referred to in the first column is made up according to G. J. Mulder's highly elaborate researches on this subject.—*Chem. News.*

ON THE METHODS AND RECENT PROGRESS OF SPECTRUM ANALYSIS.

BY A. S. HERSCHEL, B.A., F.R.A.S.

[Professor of Natural Philosophy in the Andersonian University of Glasgow.]

THE portion of the solar spectrum which is most generally visible under all circumstances of the atmosphere, and in which the bright-line spectra of the metals obtained with the spark of a Rhumkorff coil are mostly seen, is that contained between the Fraunhofer's dark lines A and G, at the least and most refrangible ends of the spectrum as it appears in Kirchhoff's maps, the last of which was published in 1863. The air-spectrum between the poles of an induction coil was subsequently employed by Mr. Huggins in his "Researches on the Spectra of some of the Chemical Elements," published in the *Philosophical Transactions* for 1864, as a standard of comparison with the bright-line spectra of the metals produced together with it in the induction spark. The superior heat of the voltaic arc being found to produce more vivid spectra of the elements, and to exhibit lines in the violet portion not usually seen with the induction coil, a blue line in the spectrum of lithium was thus discovered by Professor Tyndall in addition to the orange line which Dr. Bunsen had detected in it by the application of a Rhumkorff coil. To extend Kirchhoff's scale of reference to the wider range of artificial spectra, the labor of completing the map of the solar spectrum by delineating the violet portion, and comparing it with the voltaic spectra of the chemical elements was carried out by Professor Angström, with the assistance of Mr. R.

Thalén, at Upsala; and the work was published in the *Proceedings of the Stockholm Academy* for February, 1865. Confining their attention chiefly to the iron spectrum produced by two stout iron poles of a Bunsen Battery of 50 cells, the specimen of this metal was found to contain so many bright lines, especially in the violet portion, that, in addition to 73 iron lines found by Kirchhoff and Hofmann to have counterparts in the dark solar lines between A and G, about 220 were added to the number in that space and 170 more between G and H making the whole number of iron coincidences about 460, to which, it was believed, one or two hundred might have been added, had not the short summer and deficient sunlight in the high northern latitude put an end to their comparisons. With a greater battery power, and an equally extensive trial of other chemical elements, whose vapors appear to be present in the sun, the probability was suggested that the innumerable black lines of the solar spectrum, which still remain outstanding when those of iron are subtracted, may at length be accounted for without assuming the existence of chemical elements in the solar atmosphere, with which we are unacquainted on the earth. The solar character of four new sodium lines, which were first pointed out and their coincidence with Fraunhofer's was suspected by Mr. Huggins in his researches, was confirmed; while the agreement of a prominent dark line about half way between G and H, designated *h* by the authors, with a fourth line of the spectrum of incandescent hydrogen was established, proving with the correspondences of the other lines at C, F and G, the existence of that element in the sun. The metal manganese was placed, for the first time, on the list of solar elements, and 50 new correspondences of calcium lines were noted in addition to those already previously observed by Kirchhoff. In a Swedish work on spectrum analysis,* published in the following year, Mr. Thalén has compiled a very complete chart of spectra of the chemical elements, referred, like the above-mentioned chart of Mr. Huggins, to the bright lines of incandescent air, and continued, as far as they could be traced, to the violet end of the spectrum. It will easily be perceived that the addition of so many characteristic bright lines in the spectra of the chemical elements, by the use of the voltaic arc, by giving greater certainty to the results, facilitates, in a corresponding degree, the practical applica-

* "Spectralanalys, Exposé och Historik; Med en Spektrelkarta." Af Rob. Thalén, Upsala, Edquist & Berglund, 1866.

tions of the spectroscope. Moreover, in order to establish a natural scale for the uniform representation of artificial spectra, Professor Angström last year published a Normal Atlas of the Solar Spectrum,* in which the wave lengths of the Fraunhofer lines are employed to delineate them, so that the spaces between them represent the differences of their wave lengths enlarged to ten million times their natural dimensions. The most refrangible Fraunhofer line, H, occupies a point at 3,933 millimetres, and the least refrangible line, A, a point at 7,185 millimetres on the map, which are ten million times the wave lengths of those lines; and the entire map, consisting of six plates of two lines each, is 11 feet 6 inches in length. The violet end of the spectrum in this projection is more compressed, and the red end more expanded, than corresponds to their natural appearance. If, however, in place of the wave lengths the number of impulses in a second, or their scale of pitch, as in musical notes, were employed for projecting the Fraunhofer's lines, a nearly natural representation of the prismatic spectrum would be obtained; and the above objection to the use of the normal scale, which may not, however, be of very great theoretical importance, might yet practically be removed with some advantage. A series of elementary bright-line spectra, showing their counterparts among the solar lines, is laid down in the margin of the map, with the following numbers of the corresponding lines of each, in their correct places on the scale, viz:—Iron, 450; titanium, 116; calcium, 68; manganese, 63; nickel, 35; cobalt, 19; chromium, 18; barium, 10; sodium, 9;† magnesium, 7; copper, 7; zinc (blue lines), 2; aluminium (violet lines), 2; hydrogen, 4. By a series of remarkable coincidences, if not of absolute agreements, twenty-four lines of titanium, twenty-one of calcium, and four lines of manganese, are represented in the map as corresponding exactly in their positions with iron lines. A similar agreement between a double line of nitrogen and a double line of oxygen was observed by Mr. Huggins in the spectrum of incandescent air,‡ but as the correspondence appeared, on closer examination, not to be absolutely perfect, it was shown to be

* "Spectra Normal du Soleil;" par A. J. Angström, Upsal, 1868. The plates are drawn by Mr. Thalén.

† Three of the new lines of the sodium spectrum are double, like the familiar D line, and the fourth is a narrow nebulous line, making the total number of nine separate bright lines in the spectrum of this vapor.

‡ "Researches on the Spectra of some of the Chemical Elements." *Philosophical Transactions* for 1864, part ii.

probably an accidental, although certainly a most curious, coincidence. In Angström's Normal Atlas the air spectrum is placed on a parallel line with the solar spectrum, extending throughout its length so as to include the lines of the elementary spectra between them. The comparison of the latter with either of the two standard scales is, accordingly, made a matter of easy reference. At the end of the atlas is placed a chart of the atmospheric dark lines and spaces of the solar spectrum, a large number of which are now known to owe their presence in it to the absorption produced by aqueous vapor in the earth's atmosphere. This cloudy group of lines is well characterized by Mr. Thalén as forming a faint ground, from which the true solar lines of the inverted metallic spectra, tolerably deep black and well defined, stand out, as if seen in perspective, in strong relief. In place of the four glass prisms used by Mr. Kirchhoff in his researches, a single bisulphide of carbon prism with a refracting angle of 60° , a collimator, and an astronomical telescope, each magnifying forty times, were found to be a sufficiently powerful apparatus to distinguish all the lines shown in Kirchhoff's maps, and to add to them the numerous lines recorded in the above-mentioned drawings by Mr. Thalén. From the foregoing description of their recent publications, it will be seen that the operations of the Swedish observers continue to afford fresh data of practical value to spectral analysis, as well as some very important contributions of a novel and interesting kind of spectroscopic science.

CONTRIBUTIONS TO THE HISTORY OF EXPLOSIVE AGENTS.

BY F. A. ABEL, F.R.S., For. Sec. C. S.

THE degree of rapidity with which an explosive substance undergoes metamorphosis, as also the nature and results of such change, are, in the greater number of instances, susceptible of several modifications by variation of the circumstances under which the conditions essential to chemical change are fulfilled.

Excellent illustrations of the modes by which such modifications may be brought about are furnished by gun-cotton, which may be made to burn very slowly, almost without flame, to inflame with great rapidity, but without development of great explosive force, or to exercise a violent destructive action, according as the mode of

applying heat, the circumstances attending such application of heat, and the mechanical condition of the explosive agent are modified.* The character of explosion and the mechanical force developed within given periods by the metamorphosis of explosive mixtures, such as gunpowder, is similarly subject to modifications; and even the most violent explosive compounds known (the mercuric and silver fulminates, and the chloride and iodide of nitrogen,) behave in very different ways under the operation of heat or other disturbing influences, according to the circumstances which attend the metamorphosis of the explosive agent (*e. g.*, the position of the source of heat with reference to the mass of the substance to be exploded, or the extent of initial resistance opposed to the escape of the products of explosion).

Some new and striking illustrations have been obtained of the susceptibility to modification in explosive action possessed by these substances.

The product of the action of nitric acid upon glycerine, known as nitro-glycerine or glonoine, which bears some resemblance to chloride of nitrogen in its power of sudden explosion, requires the fulfilment of special conditions for the development of its explosive force. Its explosion by the simple application of heat can only be accomplished if the source of heat be applied, for a protracted period, in such a way that chemical decomposition is established in some portions of the mass, and is favored by the continued application of heat to that part. Under these circumstances, the chemical change proceeds with very rapidly accelerating violence, and the sudden transformation into gaseous products of the heated portion eventually results, a transformation which is instantly communicated throughout the mass of nitro-glycerine, so that confinement of the substance is not necessary to develop its full explosive force. This result can be obtained more expeditiously and with greater certainty by exposing the substance to the concussive action of a detonation produced by the ignition of a small quantity of fulminating powder, closely confined and placed in contact with, or proximity to, the nitro-glycerine.

The development of the violent explosive action of nitro-glycerine, freely exposed to air, through the agency of a detonation, was regarded until recently as a peculiarity of that substance; it is now demonstrated that gun-cotton and other explosive compounds and

* *Proceedings of the Royal Society*, Vol. XIII., pp. 205 *et seq.*

mixtures do not necessarily require confinement for the full development of their explosive force, but that this result is attainable (and very readily, in some instances, especially in the case of gun-cotton,) by means similar to those applied in the case of nitro-glycerine.

The manner in which a detonation operates in determining the violent explosion of gun-cotton, nitro-glycerine, &c., has been made the subject of careful investigation. It is demonstrated experimentally that the result cannot be ascribed to the direct operation of the heat developed by the chemical changes of the charge of detonating material used as the exploding agent. An experimental comparison of the mechanical force exerted by different explosive compounds, and by the same compound employed in different ways, has shown that the remarkable power possessed by the explosion of small quantities of certain bodies (the mercuric and silver fulminates) to accomplish the detonation of gun-cotton, while comparatively very large quantities of other highly explosive agents are incapable of producing that result, is generally accounted for satisfactorily by the difference of force suddenly brought to bear in the different instances upon some portion of the mass operated upon. Most generally, therefore, the degree of facility with which the detonation of a substance will develop similar change in a neighboring explosive substance, may be regarded as proportionate to the amount of force developed within the shortest period of time by that detonation, the latter being, in fact, analogous in its operation to that of a blow from a hammer, or of the impact of a projectile.

Several remarkable results of an exceptional character have been obtained, which indicate that the development of explosive force under the circumstances referred to is not always simply ascribable to the sudden operation of mechanical force. These were especially observed in the course of a comparison of the conditions essential to the detonation of gun-cotton and of nitro-glycerine by means of particular explosive agents, (chloride of nitrogen, &c.,) as well as in an examination into the effects produced upon each other by the detonation of those two substances.

The explanation offered of these exceptional results is to the effect that the vibrations attendant upon a particular explosion, if synchronous with those which would result from the explosion of a neighboring substance in a state of high chemical tension, will by

their tendency to develop those vibrations, either determine the explosion of that substance, or at any rate greatly aid the disturbing effect of mechanical force suddenly applied, while, in the instance of another explosion, which develops vibratory impulses of different character, the mechanical force applied through its agency has to operate with little or no aid; greater force, or a more powerful detonation, being therefore required in the latter instance to accomplish the same result.

Instances of the apparently simultaneous explosion of numerous distinct and even somewhat widely separated masses of explosive substances (such as simultaneous explosions in several distinct buildings at powder-mills,) do not unfrequently occur, in which the generation of a disruptive impulse by the first or initiative explosion, which is communicated with extreme rapidity to contiguous masses of the same nature, appears much more likely to be the operating cause, than that such simultaneous explosions should be brought about by the direct operation of heat and mechanical force.

A practical examination has been instituted into the influence which the explosion of gun-cotton, through the agency of a detonation, exercises upon the nature of its metamorphosis, upon the character and effects of its explosion, and upon the uses to which gun-cotton is susceptible of application.—*Chem. News.*

A New Air-Pump.—An instrument of this nature has been lately devised by Bunsen, which, as a stationary attachment to a laboratory will, no doubt, prove of great and general service. It consists, essentially, of a concentric nozzle at the top of a small lead pipe, about $\frac{3}{8}$ inch = 8 millimetres in diameter, and about 40 feet long, having a water supply flowing through the outer part of the jet, and sucking air in a series of bubbles from the inner jet, which is connected with the vessel to be exhausted. This arrangement will, at any time, give a vacuum equal to the tension of the vapor of water at the existing temperature. To exhaust a flask of 1 to 3 litre ($\cdot 88$ to $2\frac{1}{2}$ quarts) requires from 6 to 10 minutes, and expends 40 to 50 litres ($8\frac{1}{2}$ to $10\frac{1}{2}$ gallons) of water.

The advantage of being able to *turn on a vacuum* with a stop-cock, and exhaust corrosive gases without injury to apparatus, afforded by this device, is of very great importance.

EDUCATIONAL

SPECTRUM ANALYSIS.

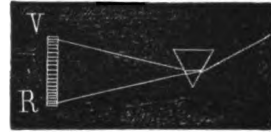
BY PROF. HENRY MORTON, PH. D.

THE subject of spectrum analysis is one, which, by reason of its rapid development in connection with practical matters and the general business of life, is at present exciting the interest of many who have not before given to it any attention. Like every other great and new discovery, it excited interest among a certain class, at first, by a mere force of novelty, but failed by that claim to establish its value in the eyes of the general community. But it has now reached that stage of development when its claims must be recognized by all, and thus many of those who ignored its early developments and primitive stages of advance, now are asking for information as to its character, principles and applications; and for their benefit we propose to publish a concise account of the first principles of this wonderful process, by means of which we are enabled to deal at equal advantage with the inappreciably small and the immeasurably great; to discover the presence of the one two hundred-millionth of a grain of salt floating in the air, and to analyze every star and nebula in the universe. By which we can look into and follow more closely than by any other aid, those mysterious changes in the structure of substances which are concerned in the microscopic phenomena of life; and with which we can likewise detect the changes which may be progressing in the growth of a solar system, and translate to our comprehension the passing incidents in the physical history of an universe.

The elementary facts and principles upon which this wonderful process is based are, after all, few and simple. If a ray of white light, passing through a narrow crack, so that it might be represented in its entire path by a strip of paper, falls upon a glass prism so as to have its narrowest edges towards the triangular ends, and its breadth parallel with the three parallel edges of the glass, it will be bent from its course, as is shown in the figure, and, moreover, will be spread out so as to produce on a screen a band or ribbon of light which will have a red color at the end, R, a violet color

at the other end, *v*, and all the other pure colors, orange, yellow, green, blue, with all their possible gradations, blending gradually between. Such a band of colored light is called a "spectrum," or, accurately, a "continuous spectrum."

Fig. 1.



The significance of this simple experiment will be appreciated when the following facts, proved in many other ways beside, are borne in mind:—

White light is a composition of all pure colors, and the simple, or pure and unmixed, thing, in light, is not white, but any single color. Each simple color is bent or deflected by a prism, to a certain degree peculiar to itself; and thus, when the mingled white ray falls upon the prism, each of its constituent colors, being differently deflected, follows a different path, and so comes to a different place; and thus the individual tints are "deployed in line," and appear side by side.

Were the ray which falls upon the prism composed of a single color, no such outspreading could occur; all the light would be equally bent, would follow the same path, and would produce on the screen a narrow line exactly similar in shape to the opening through which the beam was admitted at first. Thus, if the light were of a simple red tint, it would go to some point near *R*; if of a violet shade, to some one spot near *v*; or if orange, yellow, or green, to its appropriate place between the first-mentioned extremities.

If, again, the color in the light were mixed—if the ray consisted of a certain yellow ray and a certain blue one combined—then, after traversing the prism, the blue part would go to its place, and the yellow to its own, and the rest would be unilluminated or dark. Thus would the mixed light be "analyzed" by such a development into an incomplete and fragmentary spectrum, which is, however, called a "spectrum," nevertheless.

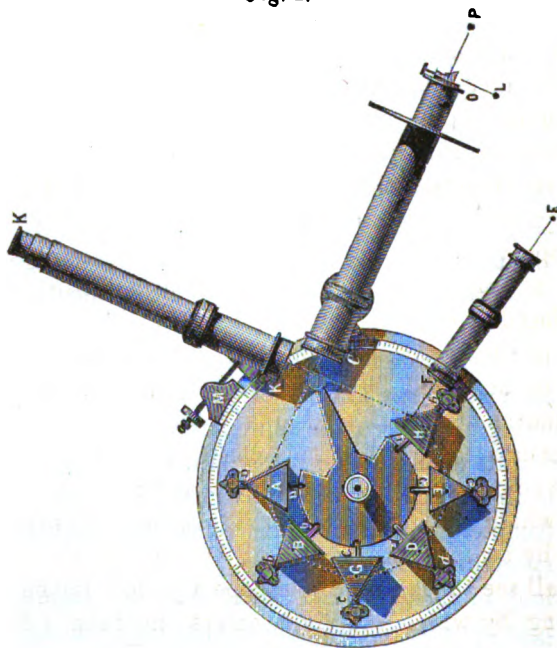
We should further mention here, that the difference between colors in light is exactly the same as that between notes in music, namely: a variation in the rapidity of vibration. Thus, the note *c*, or "do," of the lowest octave, is produced by, or consists of, 128 vibrations per second; *d*, or "re," of 144, and so on; and in like manner crimson light is produced by 473,000,000,000,000 vibrations per second, and bright blue by 653,000,000,000,000.

The separation effected by the prism in the case before described, is, therefore, in fact, a sort of numerical classification by which the vibrations of different rates are sorted out, and each sent to its own place in the rank, according to a regular numerical progression. To follow out our musical analogy or illustration, it would be paralleled in the case of sound, could we, by some sort of acoustic prism, separate the various notes coming from an orchestra, and cause each to fall in its appropriate place on the key-board of a piano.

The general principle being such as we have above described, the method by which it is practically applied to purposes of analysis is as follows:—

An instrument called a "spectroscope" is provided, which is constructed in the following manner (see Fig. 2, which is a view of the apparatus as seen from directly above): Attached to a firm

Fig. 2.



stand having a flat circular top, is a tube, *c o*, having at its end, *o*, a narrow vertical opening adjustable as to its width by means of a slide and screw. Half the height of this opening is covered by a small triangular glass prism, by which rays of light from *L* will be

reflected into the tube through that half of the opening, while the other half is uncovered and will admit light from P, directly in front.

We will at first only consider these last rays, which may be supposed to come from a lamp or burner at P, and to pass down the tube, c o. At the end, c, of this tube, these rays encounter a lens, which renders them parallel to one another, and in this condition they fall upon a prism, A, by which they are refracted and separated in the manner already described, and fall, in turn, upon a prism, B, which bends them around to c; this then sends them to D, and so on to H, from which they pass off in the direction H K, and thus enter this tube, K K, which is simply a small telescope, to the outer end of which the eye of the observer is applied.

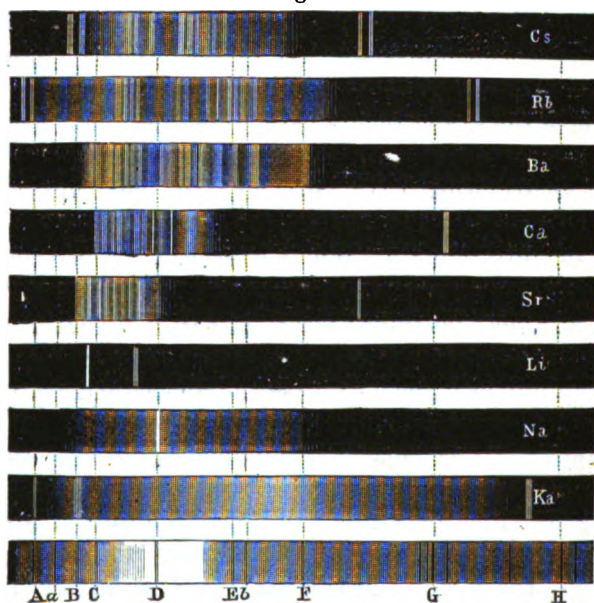
It is not always or generally necessary to employ so many prisms. Ordinary instruments have only one, the telescope being then placed so as to receive the rays as they leave this first and only prism in the direction A B. Where so many prisms are used, moreover, all the rays cannot be seen at once, as, after the second prism, they are so widely outspread that only part of them fall upon the next prism, and so on, more and more to the last: an arrangement is therefore provided (such as we see in the figure) for so turning all the prisms together that one part after another of the outspread band of rays or "spectrum" will fall upon and be observed through the telescope.

If, then, a source of white light, such as a candle, lamp, or gas-flame is placed at P, its various colored rays will be separated by the action of the one or more prisms employed, and the distributed, separated, or analyzed light or "spectrum," will be observed in detail by means of the telescope at K.

If, however, a source of light is placed at P, which furnishes rays of but one color (as, for example, a spirit-lamp with table salt on the wick, which gives pure yellow light), then the rays will not be separated by the prisms, but will all be bent equally and together, and we shall see through the telescope a yellow image of the narrow opening by which the light enters the tube, c o, exactly as though we were looking directly towards it. This image will occupy exactly the place of the same color (yellow) in the continuous spectrum obtained with the white light. In fact, we may very fairly regard the continuous spectrum as being made up of a row of colored images of the narrow opening, arranged side by side: this

arrangement being due to the fact that each color is differently bent by the prisms. If the light placed at P, instead of emitting one color, gave out two, three, four, or more distinct colors, but not every shade, then each of these tints would be thrown to its appropriate place, and we should have a spectrum consisting of two, three, four, or more colored bands distributed on a black ground. This is illustrated in Fig 3, where all the "spectra," except the last, are of this character.

Fig. 3.



It is a fact, proved by extended observation and experiment, that when substances are so heated as to be vaporized and made luminous at the same time, the light which they emit is made up of a moderate number of colors, wanting a great part of the various shades which would make up a complete series or continuous spectrum; and that, moreover, the colors emitted by each substance are peculiar to itself, and, under similar conditions, always the same for the same body. If, then, we heat an unknown substance in the colorless flame of an alcohol lamp, or Bunsen burner, and look at the light its vapor emits, through a spectroscope such as is shown in Fig. 2, and we see a single vertical yellow line, as in the band marked Na. on Fig. 3, we may know that the substance employed contains sodium. If we see a rich red and an orange line,

as in band marked Li., we know that lithmus is present, and so on with the others, Sr. standing for strontium, Ca. for calcium, Ba. for barium, Rb. for rubidium, Cs. for cæsium, and Ka. for potassium.

These lines are here shown without their colors, but these may be estimated by remembering that the lower band represents a spectrum of sunlight with its red end at A, bright crimson at C, orange at D, and yellow beyond; green about E, blue beginning about F, indigo near G, and violet either side of H, and that like colors occupy corresponding places in the bands below.

For the more accurate determination of lines, measurements are made by means of a transparent scale placed in the outer end of the tube, F, and illuminated by a light at F, its image being reflected from the face of the prism H so as to enter the telescope, K, along with the rays producing the spectrum, so that the divided scale seems to be a transparent rule lying upon the spectrum.

The object of the little prism at the end of the tube, C O, is to enable us to compare the spectra of the two lights, one being placed at L and one at P. The light from P goes through the part of the slit not covered by the prism, while that from L goes by the other part, and so two spectra are seen at once, one above the other.

By the use of such an instrument as we have described, it is evident that the presence or absence of a large number of substances in minerals, and like bodies, may be ascertained with great ease and rapidity. To facilitate such operations, a few adjuncts are of great advantage. Thus, beside a pair of Bunsen burners of the usual sort, a couple of light stands, furnished with projecting adjustable wires, over which short pieces of glass tubing with platinum wires attached to their outer ends will slip. These platinum wires, bent into a loop, will hold in the flame of the burners, morsels of the substances to be tested. Where a higher temperature than that of the Bunsen burner is required, the oxohydrogen flame is sometimes employed; but, usually, those substances which will not volatilize in the ordinary Bunsen burner, must be treated with the vastly higher temperature of the electric discharge. This is most conveniently obtained by the use of the induction coil with Leyden jars in circuit. The substances to be examined are then adjusted as terminal points, between which the spark leaps either in the air or within glass tubes; or, if the material be liquid or gaseous, it is enclosed in a tube more or less exhausted, and supplied with conducting wires soldered into its ends.

By extended investigations, certain laws or general rules of action have been developed in reference to the relation of various forms of matter and their spectra, which are of the greatest importance, on account of their application to the solution of many natural problems otherwise quite beyond our reach. This subject we must, however, defer until the next number.

(To be continued.)

ON THE FUTURE DEVELOPMENT OF SCIENTIFIC EDUCATION IN AMERICA.

BY S. EDWARD WARREN, C. E.

Prof of Descriptive Geometry, &c., in the Rensselaer Pol. Inst., Troy, N. Y.

(Concluded from Vol. LVII., page 422.)

(D.)—*Philosophy.* Passing over, without further comment, than has already been made, such classes of studies as are at present popular and appreciated, and noting only those which are misapprehended and regarded with some prejudice, philosophy must have a word in its behalf. It is no wonder that those who deal with obviously fruitful facts and thoughts, and who have been well nigh consumed with laughter, in reading of the successive and dissimilar rocket flights of some philosophies, and at the transient and very much unmeaning applause that greeted each, should think the very word philosophy a synonym for such ingenious vagary, as any one could write to order by the yard, for the amusement of a lively company. But there is a philosophy, of plain sound Scotch, or other common sense, to which a dash of French brilliancy does no harm; which consists in an orderly discussion of facts and principles; well ascertained by patient interrogation of consciousness, and observation of life, similar to those employed in physical researches. Such philosophy must be both interesting and improving, by as much as the human spirit is a reality, having ascertainable attributes and relations.

We only add, that philosophy is here used in a broad sense, to include *Psychology*, or mental structure; *Logic*, or the science of the necessary forms of thought, *Ethics*, or moral science, and *Æsthetics*, or the science of beauty.

(E.)—*Practice.* Man, considered as not a *structure*, merely, but an *agent*, to be perfected; and, still more, as a *complex*, and not a

simple agent, since he is composed of a united body and spirit, should be trained by a thoroughly concrete system of education; that is, one in which manipulations, governed by principles, and resulting in visibly or tangibly *embodied* principles, shall have a due share. For the spirit to keep the flesh forever innocently busy, in working out some work of the governing intelligence, is not merely an incomparable moral safeguard, and that in the sweetest way, by securing perennial delight in life, but it educates the actual concrete man, of body and soul, up to a perfect practical unity of being, by making the body the sure and accomplished servant of the soul; by putting every physical capacity fully into the grasp of the *self*-possessed spirit. Physical, chemical, geodetical, graphical, gymnastic and vocal *practice*, with a full understanding of the principles involved, is a grand division of noble educating agencies, which have not always been sufficiently recognized, even in otherwise masterly and comprehensive reviews of the business and objects of education.

Moreover, it is in the light of these remarks, and more clearly than before, perhaps, that we see, that general, or "liberal," and technical or "professional" education are properly less distinct in real life, than in systems of thought.

(F).—Observation and experiment, we would now thus unite.

Observation	{	Simple = Of <i>Free</i> Man and Nature.
		Condition = Of humanly conditioned Man or
		Nature = Experiment.

With these comments we proceed with the final two years of the proposed five years programme.

Technical Courses—Two Years.

Idea.—Without the perception of a noble idea at the bottom of technical instruction, it cannot be redeemed from the comparative disesteem evidently felt for it by some. There is such an idea of the very highest order, and only a strange failure to perceive it seems to have caused the disesteem alluded to.

The evil pride of life has apparently caused man to catch, if only obscurely, at the idea of a lofty aristocracy of learning, in connection with the idea of a university as a place of elegant retirement, for purposes of self culture, simply for its own sake. Let us therefore go at once to the foundation of life to see what can there be found, and thence, how to build.

The elements of life are being, doing, having; the perfection of each, as before said, is the sum of *good*. University, or college education, both being the same in spirit, so far as they only contemplate self-culture on the part of their members, aim in this spirit, to make perfection of *being* alone their end, in other words to make man an end to himself, as it is often expressed.

Now, a being so readily subject to illusions as man, may far too readily adopt the *apparently* lofty, but according to the deepest truth, belittling idea of superlative greatness in thus withdrawing from industrial life in behalf of a life of elegant self-culture; supported by the industry of others, and earning for him an obsequious regard, which is in reality superstitious, as the following considerations shall plainly show; premising that we mean by superstitious regard, a deference beyond and in place of that which is *naturally* due, according to the real truth of things.

Professional education aims to perfect the *doing*, and that for the sake of the *having*, which perfect *doing* will certainly secure. Now, it is just here that a fatal oversight is made. First, there is nothing necessarily ignoble in study pursued in behalf of material self-service. For the actual world being most thoroughly a concrete one of matter united with and subject to controlling life, the *form* and *quality*, not necessarily the *amount*, of one's material acquisitions, are a fair exponent or expression of his capacities and personal soundness and worth. God has conditioned beautiful practical living, in which material things possessed are wielded for spiritual ends, upon well directed industry. Each is therefore bound to show to all, *his* characteristic specimen of the beautiful results of *his* peculiar form of industry. But, second, service is not by any means necessarily self-service.

It is not so in *effect*, even if so in *spirit*. But it is not necessarily so in spirit. And, now, can a noble progression end in a nobler conclusion than this following? Perfection of *being*, that the being, as an instrument, shall be capable of perfect *doing*. Perfect doing, for the sake of perfect *having*, and this last, in its use, the practical contribution which one consciously, intentionally and gladly makes to the glory of God as his Creator; to the blessing of man as his brother.

But only technical or professional education contemplates that exact determinateness, which makes perfect doing, and effects perfect having.

Wherefore, while the spirit of general or collegiate education, when it becomes partisan and dissociated from the best ideal professional spirit, has for its motto knowledge, admiration (of self and of things which exalt self), self-exaltation, and while the professional spirit, when depraved and fallen, contemplating only *selfish* self-service, with the least of broad or deep intelligence in the use of means to that end, is only a "bread and butter" spirit; the true professional spirit, reinforcing itself by intimate union with a just university spirit, takes for its symbol: *knowledge, admiration, love, service*. *Knowledge* of that form and extent that may be universally serviceable: *Admiration* of knowledge for both its subjective and objective benefits: *Love* to the Provider at once of the knowing faculties, on the one hand, and of honorable truth on the other; and to man for whom truth is to be reduced to practice. *Service*, joyfully rendered to the Creator, for the sake of his goodness, and to the creature for the sake of his needs.

We now return to our programme. Of the special courses in an engineering school, much is common to all. The following programme, may represent the course for the section of Construction Engineers.

First Year = Division B.

SUBJECT.	NO. HOURS ON DUTY.
Rational Mechanics.	80
Physical "	40
Spherical Astronomy.....	30
Theory of Acoustics and Optics.....	25
" Structures	60
Technical Physics, Warming, Ventilation, Tests of Materials, Discharge of Liquids, etc.	60
Natural History, Origin and Preparation of Engineering Materials	30
Machine Construction and Drawing, Elements.....	50
Practical Chemistry, Qualitative Analysis.....	50
" Astronomy	60
" Trigonometry, Leveling and Topographical Surveying...	60
Hydrographical Surveying.....	60
Contour Maps	15
Hydrographical Maps	30
Structure Drawing.....	60
Contingent.....	50

750

Second Year = Division A.

SUBJECT.	NO. HOURS ON DUTY.
Engineering Geology.....	20
General and Iron Metallurgy	35
Manufacture of Machines.....	20
History and Processes of the Useful Arts.....	30
Flow of Streams, Experimental Determinations	15
History of Engineering.....	20
Practical Chemistry.....	25
“ Meteorology.....	20
Engineering Chemistry, Preservation of Materials	25
Lectures on Special Engineering Operations by Experts.....	45
Railway Administration and Economy.....	30
Machine Construction and Drawing	20
Theory of Machines, General and Locomotive Motors	90
General and Engineering Architecture	30
Stone Cutting, Carpentry and Stairs.....	55
Railroad Surveying and Construction (Lectures).....	40
Higher Geodesy, Elements.....	15
General and Engineering Jurisprudence.....	20
Engineering Aesthetics.....	20
Political Economy	25
Constitution of the United States.....	10
Road Engineering, Practice.....	40
R. R. Maps.....	20
Theses	50
Contingent.....	50

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The Cause of the Hardening of Hydraulic Cement.—In order to test the truth of the different hypotheses made concerning to this subject, A. Schulatschenko, seeing the impossibility of separating, from a mixture of silicates, each special combination thereof, repeated Fuchs's experiment, by separating the silica from 100 parts of pure soluble silicate of potassa, and, after mixing it with fifty parts of lime and placing the mass under water, when it hardened rapidly. A similar mixture was submitted to a very high temperature, and in this case, also, a cement was made. As a third experiment, a similar mixture was heated till it was fused; after having been cooled and pulverised, the fused mass did not harden any more under water. Hence it follows that hardening does take place in cement made by the wet as well as the dry process, and that the so-called over-burned cement is inactive, in consequence of its particles having suffered a physical change.

Bibliographical Notices.

WE have received from Prof. Leeds, now residing in Berlin, the following reviews and abstracts of new German publications, which will, no doubt, be of special value to our readers, as the books themselves are not likely to be easily accessible, and these full discussions may thus represent them.—[ED.]

Grundzüge der Krystallographie. By Dr. J. Müller. Second edition. Braunschweig: Vieweg & Son. 1868.

A great variety of discoveries in natural philosophy has shown that there is an intimate relation between the physical properties of substances and their crystalline form. If the three imaginary lines or axes around which the mass of a crystal is symmetrically disposed are equal in length and at right angles to each other, then are its physical properties in these three directions the same. But, if such is not the case—if these axes are unequal in length and oblique, there is, on the contrary, not only a different conductivity for heat and electricity, an unequal degree of hardness and cohesion in dissimilar parts of the crystal, but even the rays of light are dissimilarly affected. The crystalline form is the external expression of the peculiar physical properties of a substance: it reveals at a glance what otherwise could be gathered only from many experiments. Although a growing appreciation of the importance of these facts, not merely by mineralogists and physicists, but also by chemists, has caused a larger and larger space to be devoted to Crystallography in works on Natural Philosophy and Chemical Physics, yet there is still a want of a compendium in English treating of this subject alone.

This work by Müller, at present under consideration, is plentifully illustrated with good wood-cuts, is clearly written, and as an easily-understood introduction to the science has a certain small value. Something more extensive is demanded at the present time. A work is wanted which will give the fundamental forms and all the known modifications. The different systems of lettering should be given, and the relation between the secondary and primary forms thoroughly explained. Something of this kind is requisite even to the mineralogist, to enable him fully to understand those

portions of the last edition of Dana's Mineralogy which relate to crystalline forms. For the system there given, though admirable for simplicity and conciseness, and though it expresses to an accomplished crystallographer already familiar with the classic works of Haüy, Levy, Weiss, Miller, Rose, and Naumann, all that can be said about the form of a crystal, yet from its very brevity, misleads the beginner. Mere figures and letters do not constitute a language, and the beginner finds, after reading over a table of measurements such as is given in Dana, he is still unable to form a clear conception in his own mind, or to express his ideas to others, for want of words to clothe them. Every form that is mentioned in such a treatise should be accompanied by a statement of the most important substances, mineral and organic, natural and artificial, where it occurs. In like manner, all the hemiedral, hemimorphic, and twin crystallizing bodies should be fully mentioned. Practical instructions should be given for the measurement and draughting of crystals, and so much of mathematics, as would enable any one with a knowledge of trigonometry to calculate the axes and forms from observed angles. The aid afforded by cleavage and the employment of polarized light in the determination of a crystal should likewise be carefully explained. Other matters, such as the deportment of the crystals to heat, electricity, magnetism, and to light in general, their hardness, the connection between the crystalline form and chemical constitution, including the topics of isomorphy and heteromorphy, all these subjects, which are generally included, might be profitably left to special treatises, and the space thus gained devoted to the actual wants of the beginner that have been mentioned above.

Beiträge zur Geschichte der Chemie. By Hermann Kopp. Braunschweig: Vieweg & Son. 1869.

The object of these contributions to the History of Chemistry is to make known the views which have been held at different times concerning the earliest pursuit of chemistry under the form of alchemy, and the earliest writers and manuscripts referring to this subject which have come down to our knowledge and possession. The learned author, with much care and toil, has rumaged amid a multitude of musty books and long-forgotten writers, and brings these records of the folly and credulity of the past to augment the volume of chemical literature of the present day, a stream so fraught

with blessing and delight to the great masses of mankind. Few chemists will have the leisure, and many will lack the ability, to read these curious philological essays, which include, among other things, the fables and theories concerning the origin and early knowledge of alchemy; opinions concerning the knowledge of alchemy by the ancients; earliest occurrence of the word *Chemie*; the early employment of alchemy in Egypt; the oldest chemical manuscript; the old alchemical writers in general: Democritus, Lynesias, and Zosimos. A lengthy chapter on the History of Distillation is given in conclusion. In reading the chapter devoted to the first of the topics above mentioned, we cannot but feel greatly surprised at the manner in which many passages occurring in ancient authors, were wrested from their plain and obvious meaning by the writers who came afterwards, and who wrote on alchemy, and were invested with mysterious significance. For example, the passage of Genesis, (Chap. vi. 1, 2 and 4,) "And it came to pass, when men began to multiply on the face of the earth, and daughters were born unto them, that the sons of God saw the daughters of men that they were fair; and they took them wives of all which they chose. * * * There were giants in the earth in those days; and also after that, when the sons of God came in unto the daughters of men, and they bare children unto them, the same became mighty men which were of old, men of renown." In the foregoing a tradition is regarded as substantiated which imputed a knowledge of alchemy and other mysteries to the antediluvians, on the score of their intimacy with beings of supernatural origin and powers. In juxtaposition with this passage, another is given from the book of Enoch, in the second chapter of which it is told how many angels inclined themselves to the daughters of men, and what they did in consequence; one especially, (and that nothing may be lacking to the fullness and particularity of the narrative, even his name is given,) Azâzél, taught mankind "their arts; bracelets and ornaments, and (naughty angel!) the use of rouge and the beautifying of the eyebrows, and costly and most choice jewels and all manner of dyes, and the metals of the earth." Others of these fallen spirits taught various other heavenly mysteries, such as conjurations and astrology. The lover of classical literature can hardly fail to call to mind, in reading the above, that memorable passage in Prometheus Vinetus, in which Prometheus, who impersonates in himself the virtues of Greek mythology as Christ does those of Mosaic

origin, narrates the innumerable benefits and arts he has given to mortals. But Æschylus imputes far other and nobler motives to his sublime hero than those of an ignoble liaison. Clemens Romanus, who lived in the second century after Christ, gives both his credence and condemnation to these apocryphal accounts; and still more emphatically, Tertullian, who lived a short while later. This last-named father, in his treatise on the Education of Women, inveighs furiously against these shameless angels, not only on account of many damnable arts which they taught mankind, but particularly that they should have so corrupted the native(?) simplicity of the female portion of it, "making them acquainted with sparkling stones, by which to variegate their necklaces, and golden circles to clasp their arms, and drugs from lichens to color wool, and illud ipsum nigrum pulcèrem, quo oculorum exordia producuntur!"*

Another account, referring to the connections between men and angels, is an epistle of Isis to his son Ilorus, that the angel Amnael had appointed to those who sought his favor, as a reward for their compliance, that he should teach them the mystery how gold and silver are made, and that he had also so done.

Among these idle stories, there is one, however, which deserves mention as a curious interpretation of an important Grecian myth in the Chronicle of John of Antioch, who is placed in the seventh or in the first half of the eighth century, is the statement: "The Golden Fleece of which tradition speaks, was a declaration written upon sheepskin, how by means of chemie to make gold."

This method of interpreting mythology was largely extended by other writers who, in their unbounded desire to lay hold on all things which might invest the subject of alchemy with portentous mystery, scrupled not to find latent meanings in many of the simply-written lines of the Iliad and Odyssey. As in that passage of Odys. B. VIII., v. 274 to 298, which narrates the well-known story

* The following serious foot-note, appended by the author to the foregoing, is too good, in its way, to be lost. It makes one think of some of the best passages in Knickerbocker's *History of New York*. "Here and in the following places where calliblepharum tincturæ is mentioned, as previously in the book of Enoch (s. 7), reference is made to the practice, or rather the malpractice, of coloring the eyebrows with Spiessglanz (Sulphide of Antimony), and so increasing their arch (see my *History of Chemistry*, IV. Section, Braunschweig, 1847, s. 100). The appeasing of female vanity, which was sought by these means, was regarded as having its origin in sin, and the thing itself as sinful, just as in our own time the wearing of chignons is regarded as sinful, and is opposed by the higher authority of the church.

of the love of Venus and Mars, an old mediæval commentator discovers a certain chemical mystery in which Iron in the person of Mars, and Copper as Venus, are the principal characters. So an extract from Pindar, Olymp. IX., is cited, in which the names of a number of the gods occur, and the incident narrated is asserted to have been invented to convey to the initiated an alchemical truth: Hercules is man chemical, in common language, *common salt*, born from father acid and mother alkali; Pluto earth philosophical, *sal alkali fixum*; Neptunus *Mercurius* or *alkali volatile*; Phoebus, *Sulphur*, and so on, *ad nauseam*. One author, indeed, goes so far as to assert that all the legendary tales of Greece, Phœnicia and Egypt, relate to Chemie.

But when these writings, which were invested by mediæval alchemical writers with so much occult significance, are scanned in the light of the knowledge, philosophical and scientific, which can be made to shine upon them at the present day, all such profound meanings are found to be utterly wanting. And the same remark applies to the poems of Virgil, especially the declarations of the Sybil to Æneas, (*Æneid*, B. VI., v. 136,) and to the metamorphoses of Ovid, which were thought, by Petrus Bonus, Brachescus and others, to mean alchemical transformations, as well as to certain curious Latin inscriptions. There is one passage, however, which at first seems to afford good ground for supposing that alchemical processes were regarded as feasible by the Romans in the first century of our era. It occurs in the Natural History of Pliny, where it is related that avarice tempted the Emperor Caligula to command that a huge mass of orpiment should be operated upon in the manner which he had heard was practiced in Sicily for the making of gold. But the gold resulting, though excellent in quality, was of so small amount that the emperor was greatly offended. The narrative itself, however, shows that no transmutation of metals was intended, but a metallurgical process to extract from the orpiment the frequently occurring gold percentage. Passing over a succession of later authors, we come to one in whose works we find undoubted evidence that a belief in alchemy had become general. Æneas Gazæos, a philosopher, born in Gaza, in Syria, towards the end of the fifth century, and who abandoned the doctrines of the Neoplatonists for those of Christianity. In a discourse upon the Immortality of the Soul, he says:—"Neither is it incredible that matter can be changed into a higher condition. For even among

us, those who possess a knowledge of the properties of matter, take silver and tin, and the former nature of the metal being taken away, they convert the matter itself into something more subtle and precious, and even work out the purest gold." If any one wonders, says our author, that a man could have such credulity, let him read towards the end of this discourse, where it is related with the fullest confidence in its truth, that in Lybia a confessor of the faith, after he had cut out his tongue, spoke with more ease and clearness than before. The foregoing extracts will give an idea of the nature of some of these contributions to chemical history, and to those who delight in heavy reading we commend the remainder.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, May 19th, 1869.

The meeting was called to order, with Mr. Henry Cartwright Chairman, *pro tem*. The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported the donations received at their Stated Meeting held May 12th inst., from the Royal Astronomical Society, the Royal Society, the Chemical Society and the Society of Arts, London; the Association for the Prevention of Steam Boiler Explosions, and the Scientific Students' Association, Manchester, England; l'Académie des Sciences, et la Société d'Encouragement pour l'Industrie Nationale, Paris, France; die K. K. Geologischen Reichsanstalt, die Oesterreichischen Ingenieur Veriens, Vienna, Austria; the Smithsonian Institution, Washington, D. C.; the Young Mens' Association, Buffalo, New York; the American Pharmaceutical Association, Prof. John C. Cresson, Messrs. Wenderoth, Taylor and Brown and William P. Fodell, Esq., Philadelphia.

The various Standing Committees reported their minutes.

The paper announced for the evening on Balanced Slide Valves, was then read by Mr. Thos. Adams, and was followed by a discussion upon the same subject.

The Secretary's Report was then read, after which the amendments to the By-Laws of the Institute, proposed at the last meeting, were read and adopted.

The meeting was then, on motion, adjourned.

HENRY MORTON, *Secretary*.

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Burlington, Iowa, October 2d, 1887.

DEAR SIR: I take this occasion to state to you, that for several years past I have been acquainted with the manner in which you have conducted your business as Patent Solicitor. This has always been highly creditable to yourself and satisfactory to the Patent Office. You understood your cases well, and presented them in that intelligible form which generally insured success. I make this Certificate in hopes that it may be serviceable to you in continuing to find that employment in your profession to which your industry, intelligence and courteous bearing so justly entitle you.

Yours, very truly,
To HENRY HOWSON, Esq. CHAS. MASON, Late Commissioner Patents.

Boston, October 2d, 1886.

MY DEAR SIR: It gives me great pleasure to give my testimony as to the manner in which you conducted your business as a Solicitor of Patents, during the four years that I was Chief Clerk and Executive Officer of the U. S. Patent Office, and for a considerable period Acting Commissioner.

During that time your business at the Patent Office was surpassed in extent but by one firm in New York. The papers presented by you, specifications, drawings, correspondence, &c., were invariably models of neatness, accuracy and legal precision. They were frequently pointed out to younger solicitors as among the best examples and precedents for practice in the office. Your intercourse with the office was so conducted that all the rights of your clients were secured without personal controversy. With the best opportunities of judging, I do not hesitate to say, that your thorough knowledge of mechanics and patent law places you in the first rank of the Solicitors of Patents of the United States.

Very truly, yours,

JOHN L. HAYES, Late Chief Clerk and Executive Officer U. S. Patent Office.
H. Howson, Esq., Philadelphia, Pa.

Washington, D. C., November

I fully and cheerfully endorse the statement made by Mr. Hayes in the above letter, as Howson to the patronage of the inventors of the country.

D. P. HOLLOWAY, Late Commis

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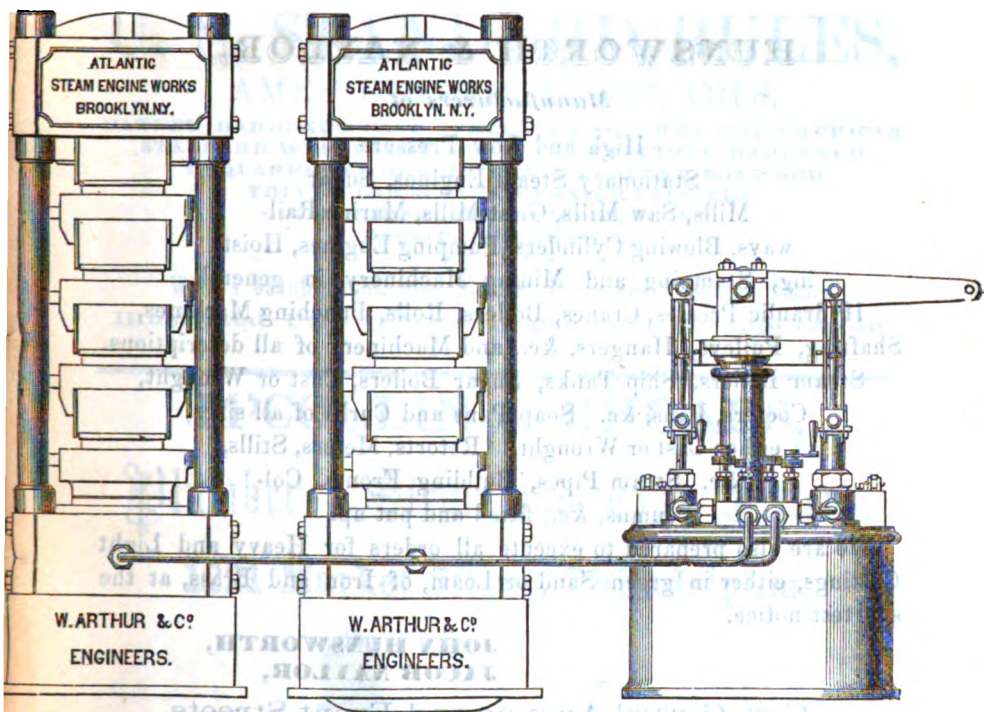
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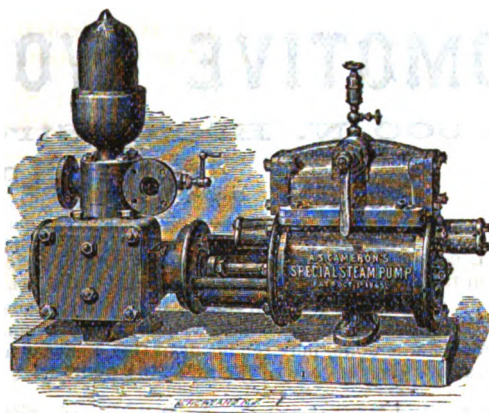
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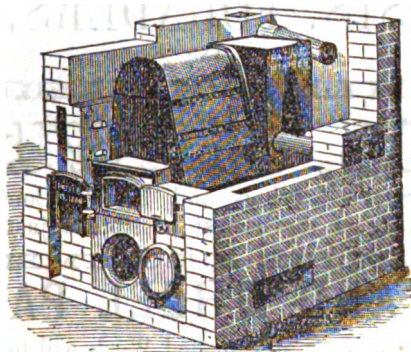
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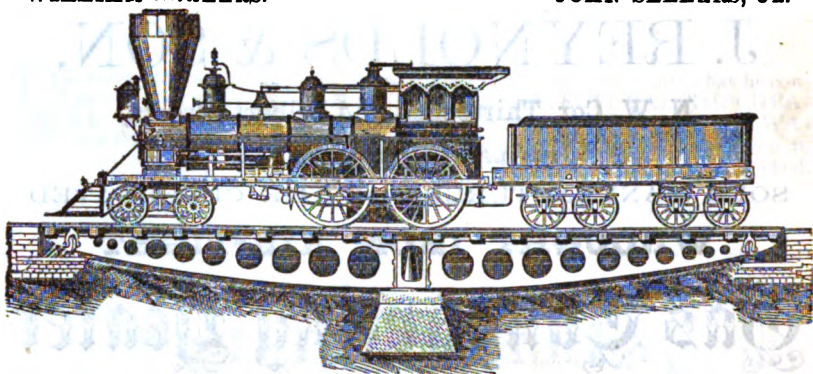
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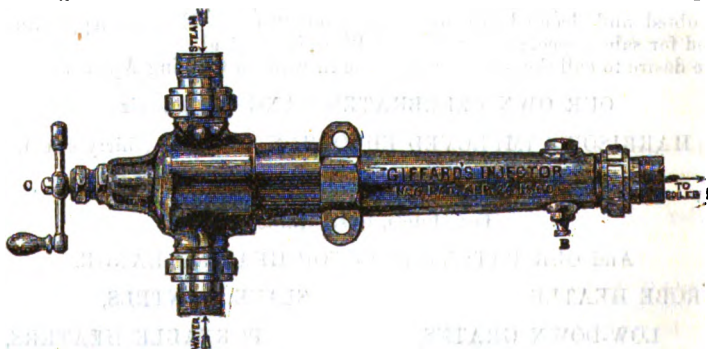
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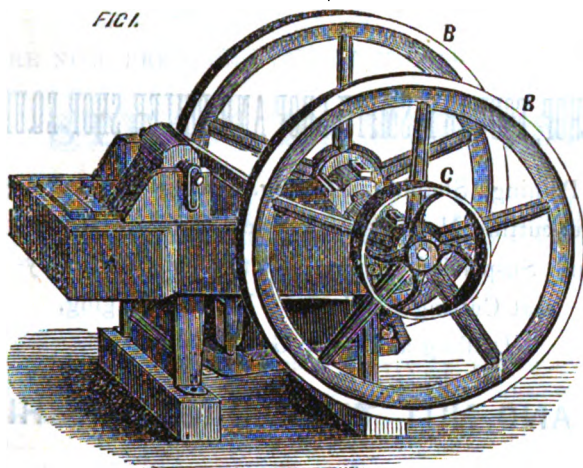
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THE
JOURNAL
OF THE
Franklin Institute,
DEVOTED TO
Science and the Mechanic Arts.

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ASSISTED BY THE COMMITTEE ON PUBLICATIONS.

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Vol LVIII.—AUGUST, 1869.—No. 2.

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OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LVIII.]

AUGUST, 1869.

[No. 2

EDITORIAL.

ITEMS AND NOVELTIES.

The Spiral Pump.—It is with much pleasure we notice the great improvements Mr. Airy has just made in an hydraulic machine of a very remarkable character, hitherto but little understood. Although the spiral pump—as Mr. Airy states at the outset of his valuable little work on the subject now under review—“was invented more than a century ago by Andreas Wirz, the tin worker of Zurich, and was afterwards made the subject of theoretical investigation by Bernoulli and Eylelwein, and in spite of the unqualified approbation bestowed upon it by all who have studied its action, the machine has been practically ignored, and as a consequence it has not received that attention to mechanical details which so greatly tends to the improvement of a machine; indeed it does not appear that more than four working specimens have ever been constructed.”

VOL. LVIII.—THIRD SERIES.—No. 2.—AUGUST, 1869.

10

The reason why so little progress has hitherto been made in the improvement of the machine is, in the opinion of the author, due to the rudeness of its construction, and we venture to add—what Mr. Airy's modesty would not allow him to do—to the very complicated nature of the theoretical investigation involved in the action of fluids moving through spiral channels, a subject Mr. Airy has evidently thoroughly investigated and made himself master of. It is gratifying, indeed, to observe that the author in dealing with this subject is able to bring to bear upon it not only the attainments of a high order of mathematical knowledge, which, as the son of the Astronomer Royal, we might perhaps naturally look for, but that thorough practical knowledge of mechanics, which we know Mr. Airy has acquired—in the only way it can be properly acquired—by going through the usual apprenticeship of the workshops.

In addition to the causes just referred to, as operating against the more general use of the spiral pump, may be added the great irregularity which has hitherto attended its working, arising from the discharge of both air and water through the vertical pipe, and the difficulty of making good the water-tight joint. Both these difficulties have, it will be seen, been successfully overcome by Mr. Airy; in the first place by the addition of a separate chamber to receive the alternate discharges of air and water through the spiral coil; and secondly, by the simple and ingenious form of leather joint he has adopted. By these means, and by carefully investigating the theory of the principles involved in its action, in which he has been materially assisted in his preliminary investigations by the use of a model with glass coils, the author has converted, what has hitherto been but of little practical utility, into a highly effective hydraulic machine, capable of raising water to great elevations, and under many circumstances, where there is an abundance of water supply even of a very low fall, it is easy to see that it is capable of most useful and economical application.

The following extracts and illustrations will enable our readers readily to understand the principle upon which these improved spiral pumps are worked; but for a great deal of other very interesting and valuable information in regard to it, we would refer them to the work itself:—*

The spiral pump is constructed as follows: A metal pipe is coiled

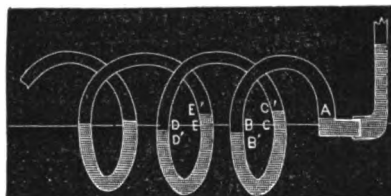
* The Spiral Pump, applied as a Force Pump, &c., by W. Airy, B. A. &c. Willis Southeran & Co., London.

round a cylindrical or conical drum, which is placed with its axis horizontal; this drum is carried by means of two axial pivots; one, a solid gudgeon, running in fixed blocks, and carrying on its end a crank, by means of which the drum can be turned; the other, a strong pipe leading into the curved end of an upright pipe, in which it turns by means of a water-tight joint; one end of the metal pipe on the drum is left open, while the other end is led into the side of the horizontal pipe-gudgeon above described, and soldered to it at the joint.

If the above machine be erected at the surface of a reservoir of water, and so placed that the drum is more or less immersed, then, as the drum is turned, the open end of the pipe that is coiled on the drum takes in a portion of air and a portion of water at every revolution; and when the drum has been turned as many times as there are coils of the pipe upon it, then the pipe on the drum is full of these fluids in regular order, the water in each coil lying at the bottom of the coil, and the air at the top (the quantity of each depending upon the depth of immersion of the drum). If now the drum be still turned, the water and air in the last coil are discharged into the horizontal pipe gudgeon of the machine, and by it into the vertical pipe; and at every additional turn of the drum an additional discharge of air and water takes place into the vertical pipe; the air at once rises to the surface and escapes, but the water remains in the vertical pipe, and establishes a column of fluid, which is supported as follows:—

Suppose that all the coils of the machine have been filled as above described, and that at the next turn of the drum, water will be discharged into the vertical pipe; also suppose that the drum is cylindrical, and is immersed to half its depth in the reservoir, so that the quantities of air and water in each coil are equal, then the position of the fluids will be as shown in Fig. 1; the drum has received the additional turn, and a charge of water has been delivered into the vertical pipe, in consequence of which the water has risen in that pipe, and a pressure column is established. The pressure of this column acting upon the surface of the air at A, and transmitting its pressure by means of the air in A B to the surface of the water at B, tilts up the column of water, B C, so as to

Fig. 1.



make it assume the position $B' C'$, and thus establishes a small column of water (equal to the difference of level of B' and C') tending to balance the water column in the vertical pipe. At the same time the water column, $B' C'$, transmits the pressure (lessened however by the portion which it carries itself) by means of the air in $C' D$ to the water surface in the next coil at D , and the water column in this coil in like manner is tilted up into the position $D' E'$, and supports a portion of the column in the vertical pipe; and the same is repeated in all the coils on the drum. These operations must not, however, be understood to follow one another in sequence, but all take place simultaneously; the water column in every coil is tilted up a little, that nearest to the vertical pipe being tilted most, and that nearest to the in-take mouth least; and the sum of the columns of support thus gained in the coils of the pipe is equal to the column in the vertical pipe; and thus equilibrium is maintained.

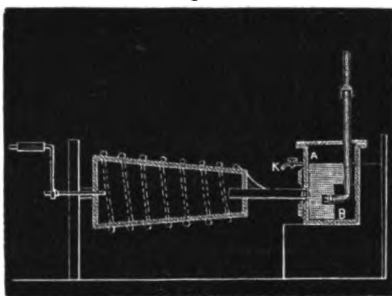
Let now the drum be further turned. Then more water is discharged into the vertical pipe, and a higher column has to be supported; and, as above described, each of the water columns in the coils will be further tilted up, the coil nearest the vertical pipe taking the greatest share of this additional tilting, and the coil nearest to the in-take mouth the least. Since, then, the water column in the coil nearest to the vertical pipe, receives always the largest share of the work of support, it is clear that the upper surface of this column will always stand higher than that of any other of the columns; and in the progress of turning it will at last arrive at the top of its coil.

If, now, the drum be further turned, the water in the last coil being incapable of doing more towards the work of support, will simply overflow into the coil next behind it, and the columns in the succeeding coils will arrange themselves (as above described), to support the additional column in the vertical pipe. In due course of time the upper surface of the water column in the last coil but one will arrive at the top of the coil; and then this column also is performing its maximum duty, and, on the machine being further turned, overflows into the coil behind it. In this way the columns in all the coils are in succession brought to their position of maximum duty, the column in the vertical pipe constantly mounting higher and higher; and finally, when the columns in all the coils are working at their maximum duty, the machine is lifting to the greatest height which it can accomplish. If now the drum be

turned the water is delivered backwards by the above-mentioned system of overflow throughout the coils just as fast as it is discharged into the vertical pipe, and no increment of height is attained. * * *

Thus far it has been assumed that the air and water are both discharged immediately into the vertical pipe; and it is in this way that all the working pumps of this kind have been constructed. But there is great inconvenience in allowing air and water to go up the same pipe; the water is discharged irregularly, with noise and shocks, and is charged with air bubbles. Also there is special inconvenience in making the water-tight joint (the only joint in the whole machine), in the curved end of the vertical pipe. To remedy these evils, the author devised the arrangement exhibited in Fig. 2,

by means of which the machine has been made to work with remarkable uniformity and success. A B is an air-tight box, and the pipe-gudgeon, C D is led into the side of A B by a water-tight joint. This joint is simple and exceedingly tight; it is merely a single thickness of leather, in which a hole is cut somewhat smaller than the pipe; the leather being se-



cured to the outside of the box, as shown in the figure, the end of the pipe is forced through the hole in the leather, which thus is somewhat coned, and its edge wraps close against the pipe; the pressure of the water acting on the side of this leather cone always tends to secure the joint, which is so tight that it does not let through a drop of water; in this joint the pipe turns with very little friction compared with that of a stuffing-box. E F is the vertical pipe; its lower end is bell-mouthed, to avoid loss of head by contraction of the fluid, and it is stepped on a block at the bottom of the box; at the top is a spout to deliver the water. K is a tap, the object of which will be soon described.

Suppose the tap, K, closed; then, as the drum is turned, air and water are poured into the box; the air, as fast as it enters, ascends to the top of the box, while the water remains below, and is forced up the vertical pipe, as already described.

In this state, the air is of great value, as the upper part of the

box then forms an air-chest (as in a fire-engine), and the expansive force of the air under pressure ensures a regular and even flow of water from the spout at the top of the vertical pipe.

It thus appears that the height to which these machines can force water is determinable simply by the number and size of the coils. The author next proceeds to show how the maximum effect varies in the proportion in which the air and water are alternately taken in at the mouth of the coil, and how the conical form of drum is preferable to the cylindrical in counteracting the prejudicial effects due to the compression of the air in the coils; the singular phenomenon of regurgitation is then noticed and explained. The adaptation of the horn to the intake-mouth, as originally applied by Wirz, the inventor, is then considered by the author, and also the curious effect it has on the arrangement of the air and water in the coils. In the Appendix full information is given for determining the number of coils for the required height, together with a great deal of other valuable data relating to the subject.

Before referring to the subject of the general application of this machine, we would just say a word in regard to a very ingenious and beautiful application of this principle of the spiral pump, referred to in the work, as being the invention of the author's brother, Mr. H. Airy; in this machine, which is appropriately called a mercury pump, that fluid is substituted for the air, and plays a very important function in its action. Owing to its much greater specific gravity, the mercury column only needs to be one-thirteenth of the height of the water column, and the description of the machine very clearly shows how ingeniously, by means of a very small quantity of mercury which is made to circulate through the coils, a continued stream of water is lifted to a very considerable height. The use of such a machine is of course but of limited application; but for hall and garden fountains, and small fancy jets of perfumed water, &c., no more suitable and effective machine could be desired.

With regard to the advantages of the spiral pump, and the scope for its useful application, we cannot do better than conclude our notice with the well put observations of the author himself on this subject:—

"The advantages of it are numerous and important. Its chief recommendation lies in the simplicity of its action, and the fewness of its parts; there are no sliding valves or other moving pieces

liable to expensive repairs, and the one water-tight joint is simple, safe, and easily renewed without skilled labor. The friction may be reduced to a very small amount, for since the drum is always more or less immersed, it will be proper to make the drum hollow and water-tight, so that by proper adjustment of its size, weight, &c., it shall float in the reservoir without bearing at all on the gudgeons. The friction of the water in the pipes is of course unavoidable, but except the velocity of rotation be very great (and this will not be advisable in any case), the friction will not be very considerable.

“The application of the machine would seem chiefly to lie in the lifting of moderate quantities of water to a considerable height, as, for example, the supply of water for domestic purposes from a stream or spring at a considerable distance below the dwellings to be supplied; if there is any fall of water, the machine could be conveniently driven by water-power, and with far greater economy than the hydraulic ram. In such a position its value would be peculiarly felt, as the stoppage of house supply is exceedingly objectionable, and this machine could scarcely anyhow get out of order except at the water-tight joint, which is renewed in a few minutes.”—*Engineering*.

Tapping a Mine.—The circumstances under which this application took place are thus detailed in the *Newcastle Daily Chronicle*: A particular seam of coal was subject to inundation from a large feeder of water, rendering a great amount of pumping power necessary in the working of the coal. The water was found to proceed from an old pit, which had been sunk many years ago to the deeper and more valuable seams, and had become gradually filled with rubbish, consisting principally of old shaft timber, stones, &c., up to the level of the seam in question, thus forming an obstruction to the water, which otherwise would have passed down the shaft and found an outlet at a lower level by means of old workings. Numerous attempts had previously been made by boring to pass the water down, but without success, the timber seeming to form an impassable barrier. Mr. Hall being favorably impressed with the success which had attended Mr. Norton's patent for sinking wells, resolved to test its capabilities in passing through a material which had been proved impenetrable to the common bore rod. Mr. Ridley, from Messrs. Mather & Armstrong, of Newcastle, licencers of the patent, undertook the management of the apparatus. An 80 pound weight and a 1½-inch tube were used. When two hours had expired from

the commencement of the operation, the tube was found to have been driven a distance of 20 feet, the speed varying considerably. The succeeding 15 feet were overcome in four hours. At this point the process became much slower, but never stationary, the next 3 feet requiring two hours labor; then 3 feet at a considerably increased speed, occupying only half an hour. The water was now laid on to the pipe and found to pass freely, and the driving was discontinued, 41 feet having been overcome in eight hours and a half. Had it been necessary, it seemed quite possible to have driven the tubes to the extreme depth of the sinking. The experiment proved a great success, and the pipes are now doing good work, and will constitute a material saving in the working of the seam, the purpose they serve being precisely the reverse of that for which they were originally intended by the patentee. It is stated that the pit contained the *debris* of one hundred fathoms of ordinary shaft bratticing, and several hundred tons of walling stones, rendered solid and compact by a quantity of ordinary pit waste-heap falling away from the surface.

A Fog Whistle, recently erected on Cape Fourcher, Yarmouth Harbor, Nova Scotia, is said to be the most powerful signal in North America, and can be heard fifteen miles in calm weather; in stormy weather five to eight miles; with the wind twenty-five miles; against the wind five to eight miles. It has been heard inland with the wind twenty-five to thirty miles.

Pin Making.—It is estimated that 1,000 persons are employed in Birmingham in the manufacture of pins, hair-pins, hooks, eyes, thimbles and eyelets. Messrs. Edleston & Williams alone use three tons of wire weekly in pin making, and Messrs. Eridge & Merritt, C. Iles, Phipson & Son, and other makers, would probably augment the total consumption of brass wire to twelve tons per week. At a moderate estimate, the number of pins manufactured weekly in Birmingham exceeds 200,000,000.

Street Railway in London.—At a meeting of the Board of Works last Friday it was determined that before sanctioning any scheme of tramways in the streets of the metropolis it would be desirable to have an experimental line between Westminster Bridge and Kennington Park, and the solicitor of the Board was directed to confer with the promoters of the bill before Parliament with a view of making arrangements for that purpose.

Old and New Coal.—Our attention has been lately drawn to a curious observation which stands, as yet, as a fact without a sufficient reason. In one case, where hard coal is used in large quantities for purposes of mere evaporation, it appears that some which has been kept on hand in open piles for five or six months, is less effective by from 13 to 15 per cent. than that freshly mined. A similar result, corresponding even in the percentage of deterioration, appears in another report from a smelting furnace. The deterioration from decrepitation, caused by absorption of water, is of course well known, but does not seem to apply to these cases.

Ship Canal across France.—The project of establishing through the valley of the Garonne (France) a canal for large navigation, to connect the ocean to the Mediterranean has been often mooted; but there is now a new plan for this undertaking, under the auspices of M. Staal de Magdoncourt, late peer of France. The proposed canal is to admit not only merchant ships of the heaviest tonnage, but also men of war and transatlantic steamers. A port is to be established in the Gironde, just below Bordeaux, and another on the Mediterranean. The cost of the scheme is estimated at 442,000,000 francs, and the cutting of the canal would occupy six years. The plan, if carried out, will materially shorten the navigable communication between England, the north of Europe and India, for it will, in fact, be a continuation of the Suez Canal.

A Cement for Joining Leather, sufficiently strong to be used for driving-belts and boot soles, may be found extremely useful. Such a cement is said by Stubenrauch to be made by mixing ten parts of bisulphide of carbon with one part of oil of turpentine, and dissolving in the mixture sufficient gutta-percha to produce a thick treacly fluid. Before it is employed, the surfaces of leather to be joined must be carefully freed from grease, and smoothed with a hot iron. The cement is then laid on both surfaces, which are now placed together, and kept firmly pressed until the cement is perfectly dry. It is obvious that boots, with soles stuck on in this way, must not be put near a fire.

Eighteen Cornish Engines were reported last month. These consumed 1,468 tons of coal, and lifted 11·7 million tons of water ten fathoms high. Average duty 53,700,000 pounds lifted 1 foot high by the consumption of 112 pounds of coal, or 479,000 foot-pounds per pound of coal. Seven engines exceeded the average duty.

Patents.—The number of visitors to the Patent Office Museum, South Kensington, for the week ending March 27, was 5,377. Total number since the opening of the Museum, free daily (May 12, 1858), 1,527,444.

Accident to a Bridge.—One of those frightful accidents which unfortunately so often accompany the carrying on of great public works occurred last Tuesday at Saltburn-by-the-Sea. An iron bridge 100 feet in length across the famous glen along which Sheltonbeck runs to the coast, was nearly completed, when an immense iron girder slipped from its holding and knocked down one of the piers, killing three men.

Silk Raising.—The *San Francisco Herald* says that those engaged in the culture of silk in California have grown no less than 1,175,000 mulberry trees. They are apportioned as follows: Los Angeles, 50,000; Santa Barbara, 100,000; Santa Clara, 150,000; Nevada, 50,000; Sacramento, 425,000; Yolo, 400,000. The total production of cocoons, in 1868, amounted to 1,350,000, equivalent to 1,917 pounds, allowing 704 cocoons to the pound, representing a cash value of \$3,676.75. To be added to this was the egg crop of 7,250 ounces, commanding in the market \$8 per ounce, amounting \$58,800. There will be a vast increase in the production of cocoons this year, as three cocooneries will hatch 600 ounces of eggs, sufficient to produce 18,000,000 cocoons.

Iron Analysis.—Gintl gives a very easy method of determining the impurities in cast iron. It is applied by him to the estimation of the sulphur contained in the iron; but, as will be seen, it is available for the separation and determination of most of the usual impurities. The iron is reduced to as minute a state of division as possible, and is then treated with a strong solution of perchloride of iron, as nearly neutral as possible. The mixture is kept heated for ten or twelve hours, at the end of which time almost all the iron will be found to have dissolved, leaving, as a residue, the carbon, sulphur, phosphorus and silicum, together with the little iron left undissolved. This residue has only to be well washed, oxidized and dissolved, and the sulphur estimated as sulphate of baryta. The exact plan directed by the author is to introduce the residue and filter into a porcelain crucible, having, at the bottom, three parts of nitrate of potash and one part of hydrate of potash; heat to fusion, dissolve and precipitate with chloride of barium. The phosphorus and silica will be contained in the same solution, and can be determined separately.

Magnesium-Light Signal Apparatus.—The Navy Department, on recommendation of the Vice Admiral, it is understood, have commenced ordering the "Magnesium-Light Signal Apparatus," designed by First Assistant Engineer, R. H. Thurston, U. S. Navy.

By this apparatus, signals are made with twice the rapidity and at less than *one-tenth* the expense of the old method of Coston colored fires. It is much more effective than the Colomb-Bolton apparatus, on which the British Government has recently expended some £15,000, as its light is not obscured by either the metal gauze or the smoke of burning resin, which are so objectionable in the English apparatus.

The U. S. Steamer "Juniata," fitting out at this port to join the European squadron, is supplied with the new apparatus.

The Eclipse of August 7th.—We are happy to learn, that, though a variety of unfortunate circumstances will prevent Mr. Rutherford, Dr. Draper, and four other experienced celestial photographers, from assisting in the observation of the coming eclipse, the great and rare opportunity will be well improved, notwithstanding. Thus, Dr. Curtis, with the Annapolis, 7½-inch Equatorial, and a corps of assistants from the Washington Observatory, is already at Des Moines, and has succeeded in making excellent sun-pictures, showing details of spots and faculæ, by way of practice.

Professor Morton has also organized a triple party, in this city, under the auspices of the Nautical Almanac Office, and has secured the High School Equatorial of 6-inch aperture, and 10 feet focal length (by Merz & Mahler, successors to Fraunhofer), with clock-work driver. The Gettysburg Equatorial, which is a duplicate of this, and a 4-inch telescope, by Dolland, belonging to the University of Pennsylvania.

Through the kindness of Mr. Scott, of the Pennsylvania Railroad, transportation in a special car, to their destination at Burlington, Iowa, and its vicinity, has been obtained for the party and instruments.

The entire party will consist of the following gentlemen :

Professor Henry Morton, Franklin Institute, Philadelphia ; Professor A. M. Mayer, Lehigh University, Bethlehem ; Professor C. F. Himes, Dickinson College, Carlisle ; Mr. W. J. Baker, Buffalo, New York ; Mr. E. L. Wilson, Mr. O. H. Willard, Mr. J. Mahoney, Mr. William Long, Mr. H. C. Phillips, Mr. J. Zentmayer, Mr. J. C.

Browne, Mr. E. Moelling, Mr. O. H. Kendall, Mr. James Cremer, Philadelphia, Pa.

This will constitute the photographic portion of the party, allowing five operators in all to each instrument. Professor J. H. C. Coffin, of the Nautical Almanac Office, will meet this party at Burlington, with an Astronomical Corps, and Professor E. C. Pickering, of the Massachusetts Institute of Technology, will go with them to make physical observations. Also Professor James McClune, the astronomer of the High School, will accompany the Philadelphia party, with instruments for astronomical work. The various telescopes have been fitted with eye-pieces of special construction and instantaneous exposure slides by Mr. Zentmayer, and with light cameras furnished by the American Optical Company, New York.

There will also be taken a Chronograph from the Washington Observatory (which has been put in excellent order) by Messrs. Chester & Patrick of this city, by means of which the dates of exposure of the various partial-phase pictures may be actually recorded and thus rendered of infinite value as astronomical observations.

A temporary observatory has been constructed in West Philadelphia, on a very convenient location, kindly placed at the disposal of the party by Mr. John Sellers, and regular drilling in the various manipulations required is being carried on there, and will continue until the time for starting arrives, which will be on the 2d of August.

The Spectrum of the Planet Uranus.—To his astonishing discovery of vapor of water in the vicinity of sun-spots, noticed in our last number, Father Secchi has added another spectroscopic discovery fully as remarkable, namely, that the light which comes to us from Uranus differs very much from that reflected by the other planets. In a number of the *Comptes Rendus* just received, (Vol. LXVIII, page 761,) we find an account to this effect. Having turned the spectroscope by chance upon this planet, then appearing as a star of the sixth magnitude, he obtained in place of the normal solar spectrum which he expected, one whose principal characteristics are indicated by the accompanying diagram, where the intensity of light in various parts



is indicated by the height of the curve. The red end of this spectrum is at the left, the violet to the right. The position of the normal sun lines *d* and *b* is indicated by those letters *N* and *M* were two very strong ab-

sorption bands located, as here shown, and corresponding to no strong solar lines. The yellow part of the spectrum was entirely wanting, as is indicated between *p* and *q*.

From this we would conclude that this planet has an atmosphere of considerable extent, and generally transparent, but absorptive of certain rays and of all yellow tints, to a considerable degree, and that the rays from the sun are not chiefly reflected to us from clouds or mists in the upper region of such an atmosphere, but penetrate it to a notable depth before they are turned back by reflection. The material of this atmosphere remains to be determined.

The Spectrum of R. Gemini.—This variable star with a spectrum like that of τ Coronæ Borealis, showing *bright* superposed lines indicative of a surrounding luminous envelope of gas, has been further studied by Father Secchi, who, in the paper quoted above, gives a diagram of its spectrum, which we subjoin. The intensity of the general spectrum is here, as before, shown



by the curve, while the positions of the bright bands, is indicated by that of the vertical lines. Two of these, *c* and *f*, it will be seen, indicate hydrogen, one, *b*, magnesium, and the double line, *d*, sodium. The first, *c* and *f*, are found likewise in the spectrum of τ Coronæ Borealis, but the others are confined to this star.

A New Regulator for the Electric Lamp.—Carié, the inventor of the ice machine which bears his name, has communicated to the Soc. d'Encouragement, a new form of battery, regulator and carbons for the electric light. Of these the most notable is the regulator, whose chief feature is the means by which the varying current gives motion to the carbons. Between the poles of an Electro magnet is an armature, shaped somewhat like the letter S, the spiral curves being so adjusted that the power of the magnet is almost equally efficient in all positions, but tends to bring the central part in line with the poles. This is resisted by the torsion of a steel wire, attached at right angles, to the armature at its centre. Thus, as the current increases in strength,  the armature, *A B*, is drawn into line with *N S*, the resistance of the spring increasing with the degree of motion. This, by simple connecting machinery, separates the points. If the current diminishes in strength, then the springs conquer, and the motions are all reversed.

Editorial Correspondence.

OUR NEW YORK LETTER.

New York, June 16th.

TO-DAY witnessed the first annual reunion of the members of the American Institute of Engineers, at their rooms No. 63 William Street. It was an interesting event to all concerned, and will be productive of much good to the profession generally, not only in establishing a warmer personal interest in each other, but also in forming another link in that bond of organization, the Society is striving to attain. The session lasted throughout the day, beginning at eleven o'clock, the morning hours being devoted to the reading of papers and general discussions, which gave way in the afternoon, to a comforting dinner, with those necessary post prandial concomitants, toasts and speeches.

The attendance was large and enthusiastic, many non-resident members coming a great distance in order to be present. The especially honored members were Messrs. J. B. Jervis and S. Whipple. The former, so well known throughout the country as one of the patriarchs of the profession, (now seventy-four years old,) and under whom a regular school of engineers developed, read a most excellent paper upon the general subject of the engineering profession, so replete with ripe experience, and good sound practical sense, that its dissemination among all grades of engineers and railway managers would be of infinite service. Its publication, of course, will shortly follow, and it is to be hoped that the Society will depart from its usual custom of not distributing its publications outside of its own members, and allow this paper of Mr. Jervis to be circulated far and wide among the profession for the good that will surely come of it.

Mr. Whipple, whose name is almost as familiar as that of Mr. Jervis, is in many respects a remarkable man. In 1847, when railways were expanding in every direction, the question of bridge building in its scientific bearing became of the utmost importance. Little was known about trussed girders, or the strength of materials,—and in England they were getting at results in the usual way, viz: by sheer "force and money," an experimental mode American engineers are not able to undertake. At this juncture, Mr. Whipple published two essays on Bridge Building, so clear,

logical and simple of application, that his manner of analysis has been practised to the present time by the best bridge engineers in the country. And not only his analysis, but forms of economical trussing, angles of braces, and general recommendations are elements of the majority of the best beam trusses built in America. It would be interesting to quote the remarks of Mr. Whipple on page 81, upon the "proposal by an eminent English engineer, Mr. Stevenson, to construct a tubular or box bridge over the Menai Straits, out of sheet or plate iron, &c."

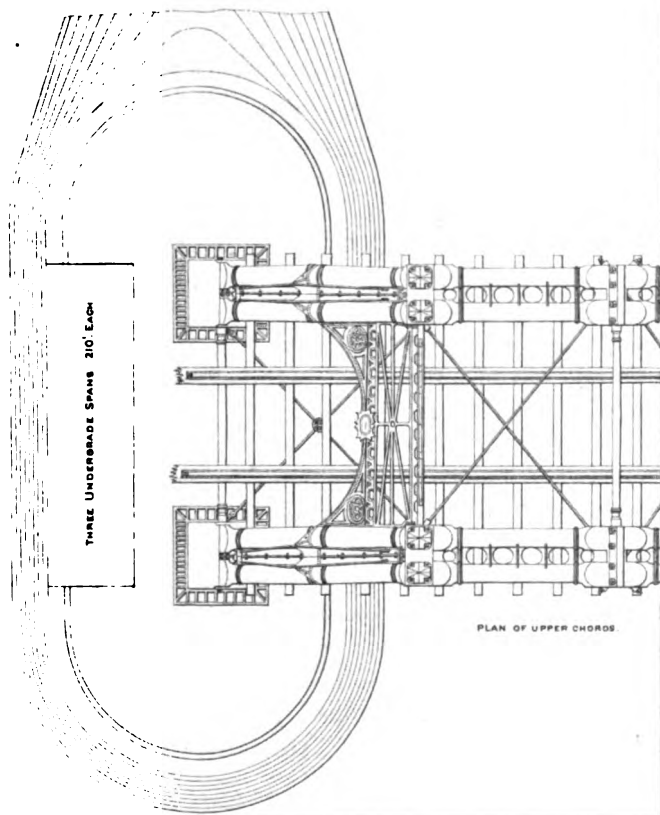
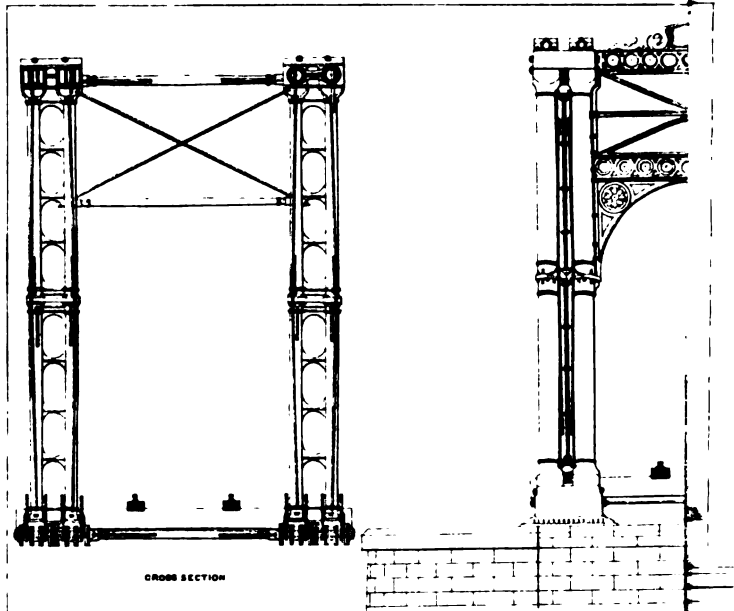
After criticising the enormous waste of material in such a beam, he suggests and estimates for an open built truss, just such a one in the main as would be built now, under the same circumstances. The different processes employed for determining the problem are interesting to note, the one based on costly experiment, supplemented by the highest mathematical talent, the other on a simple consideration and appreciation of the known laws of force, with the little data to be had on the strength of materials. Now mark the result. The first is embodied in as ponderous a piece of iron work (never to be repeated) as the world ever saw. The second, in just such a simple truss as would in principle be built to-day, and is about to be built in this country in two or three instances of spans as great as the Menai tubes. I have lying upon the table before me a *new* edition of this work of Mr. Whipple, brought up to date, and is twice as bulky as the original volume. Through some peculiar idiosyncrasy, the venerable author turned printer for the occasion, setting up the types with his own hands. It is in two parts, the first as it originally stood, the second an extension of the principles laid down in the first, together with explanatory notes, and a discussion upon counterbracing. There is also added a review and comparative analysis of the Fink, Bollman, Post and Whipple Bridges, which at this time becomes of peculiar interest, and I have no doubt this fact alone will cause much inquiry for this the best work extant on Bridge Building. To those interested it may be of service to know, that like the former edition the author keeps the present one in his own hands, and is not so careful to retain it as he used to be. There have been numerous inquiries for the first essays of Mr. Whipple, and his many known and unknown friends can now have the pleasure of testifying their appreciation of his labors. As the pioneer and teacher of Iron Bridge Building, Mr. Whipple will ever be regarded with gratitude by the profession at large, to say nothing of a deeper feeling to those who know him.

The address of the President, the Hon. Wm. J. McAlpine showed his warm sympathy and active exertion in furthering the interests of the Society, and he appealed to all present to keep up the spirit of association, and exert themselves to gather into the engineering fold all worthy members of a noble profession. The importance of such a Society as this can hardly be over-estimated, not only in the benefits reacting upon the members, but also the indirect effect upon the public at large. It is not a New York Society, but an American one in the truest sense, having members scattered over the whole of this broad country—who reap their benefits in the publications issued, which are carefully selected for their practical value. It is pleasing for a professional man, go where he will, to always find some one whom he can greet as a fellow in the same bond, who have interests in common and who feel that they are laboring toward no unselfish end, in using their best efforts for the elevation of the engineering profession.

One of these days, should the aspirations of the Society be fulfilled, they will have a building of their own, where will be found all matters of value to the engineer, and which will be, in fact, a repository of American engineering. 'Tis true, this climax is a long way off, but it is among the things that can be, should the profession cluster around the Society, as they ought to do, and it has a right to ask that they should.

Turning from such a prolific theme, to matters of more local interest, it may be interesting to note, that the long talked of East River Bridge will soon be under way, the contract having been awarded to a heavy Brooklyn firm. An eternity of boards have "sat upon" the project, and after weeks of incubation, have concluded Mr. Roebling knows what he is about, and accorded their gracious approval. The greatest interest will, of course, attach to the foundations, the engineer being prepared to go, if necessary, 100 feet below low water. The elevated railway drags its weary length along, the columns being all up as far as Thirteenth Street, the terminus of the Hudson River road. They seem still to be experimenting, but expect to have the line open by the fall. The joint interest of the Hudson River, New Haven and Harlem Railroads propose the erection of an enormous Union Depot at Forty-second Street and Fourth Avenue, which will probably be commenced in the fall.

A. P. B.



Civil and Mechanical Engineering.

OHIO RIVER BRIDGE AT STEUBENVILLE.

By J. H. LINVILLE, Engineer.

A PORTION of the masonry for a bridge to connect the Pittsburgh and Steubenville Railroad with the Steubenville and Indiana Railroad, was erected in 1856, when the work was suspended. In 1862, the Western Transportation Company having arranged to complete the Pittsburgh and Steubenville Railroad to Steubenville, a lease of the franchises of the Holiday's Cove Railroad Company, with authority to erect the bridge over the Ohio River, was effected, and the work was executed under the auspices of the Trustees.

To the writer was assigned the duty of designing and superintending the erection of the iron superstructure.

By a revised location of some of the piers, the spans were reduced to four equal spans of 235 feet each, on the eastern side, between centres of piers, and three equal spans of 210 feet between centres of piers on the western side of the channel. The piers for the channel span are 90 feet in height above low water. They are 16 feet at the top, with a batter of 1 in 24. The adjacent undergrade spans are supported in a recessed chamber, four feet deep, in the sides of the piers, leaving an available thickness of 12 feet of masonry to support the channel span. The distance between the centres of these bearings is 320 feet.

An act of Congress required the channel span to be constructed so as to afford a clear opening of 300 feet between the piers and a clear height of 90 feet above low water.

These requirements rendered it necessary to support the track of the channel span on the lower chords; an arrangement which impairs in some measure the beauty and symmetry of the entire structure.

The bridge company desiring the completion of the structure in 1863, without in any manner obstructing the channel, no system of wrought iron construction then in use appeared available.

A selection had consequently to be made from the plans of composite structures in use, none of which had been extended to spans

of so great extent. The "Linville and Piper" patent truss was modified to meet the requirements of this particular locality, and adopted by the bridge company.

The description will be limited to an explanation of the peculiarities in the construction of the span over the channel.

The trusses are divided into 24 equal subdivisions 12 feet 3 ins. each, with two end panels 12 feet 6 $\frac{3}{4}$ ins., making the entire length from centre to centre of bearings 319 feet 0 $\frac{1}{4}$ in.

The height from centre of the lower chord to the top of the upper chord, at extremities is 28 feet, the upper chord having a camber of 9 inches, the posts radiating so as to render their bearing surfaces normal to the curve of the upper chord.

The lower chords consist of 8 lines of "Linville and Piper" patent upset eye bars, graduated in section to resist the maximum effects of the dead load, and of an uniformly distributed travelling load of 3000 pounds per lineal foot of superstructure, together with the transverse strain from the floor timbers, without producing a tensile strain in these bars, exceeding 10,000 pounds per square inch of sectional area.

The lower chords and the looped ends of the suspension diagonals are combined by means of connecting pins 4 $\frac{1}{2}$ inches in diameter, the suspension diagonals being so disposed between the chord bars and ribs on the bases of the posts as to produce a shearing strain only in the connecting pin.

The upper chords consist of two similar tubes of cast iron, having an external diameter of 15 inches at centre of each section, and slightly tapering towards the ends. These two sections are combined by intermediate cast iron ribs and webs, and terminate at the abutting surfaces in two double rectangular tubes with vertical ribs, between which pass the suspension bars.

By combining these tubes, greater width of abutting surface and consequently greater lateral stiffness was obtained. Under a maximum load the strain per square inch on upper chords does not exceed 10,000 pounds. The posts are also twin tubes of cast iron, 8 inches in diameter, combined by intermediate webs and ribs, and made in two sections, with flanged ends, through which and the intermediate parting plate, pass 16 bolts 1 $\frac{1}{4}$ inches to 1 inch diameter, securely combining the two sections of the posts to the parting plates and to each other. The parting plate has four projecting pieces, with concave bearings, to receive the truss rods, which are

secured near the top of the posts, and deflecting eighteen inches, bear against the parting plate at the centre of the posts, and passing through shoulders near the bases of the posts, are adjustable by screws and nuts at their lower extremity. The posts are graduated in thickness by Hodgkinson's formulæ, the factor of safety being assumed at one-eighth of the breaking weight. The suspension diagonals consist of four square bars, varying in section in proportion to the strains, and were rolled in one piece, without welds. The lower ends have loops or eyes, $4\frac{1}{2}$ inches in diameter, which receive the connecting pins.

At the upper ends, the section of the bar is circular, formed by upsetting the iron in moulds, under immense pressure, and then swaging the ends. Screws are then cut, the available section of the bar at this point, after deducting screw-threads, being equal to the sectional area of the square bar. The upper and lower lateral rods are graduated in size, decreasing from $1\frac{5}{8}$ inches diameter at the extremities of the span, to $1\frac{1}{8}$ inches diameter at the centre. The lower lateral rods have welded loops passing through eyes in the wide eye plates, secured on the ends of the connecting pins. They meet in a ring at their intersection, and are adjustable by screws and nuts. The upper lateral rods pass through the cast iron chords, and are adjustable by nuts bearing against angle bosses cast on the chords. A system of diagonals is also introduced between the posts and upper chords, the strut being placed at sufficient height to clear the traffic.

Heavy cellular pier plates of cast iron are interposed between the bases of the end columns and the masonry.

At one end provision is made for variations in length arising from changes in temperature by means of a series of rollers secured in a frame of wrought iron. The track is supported on longitudinal timbers of white oak, resting on the transverse white pine floor timbers, which are sustained by the wide thin eye bars that constitute the lower flange or chord. In consequence of the heavy Government contracts incident to the late civil war, and the scarcity of skilled labor, great delay was experienced in procuring the requisite materials; and the progress of the work was frequently interrupted. The erection of the shorter spans was begun in 1863. The channel span not being completed ready for erection during the stage of low water in 1864, its erection was deferred until the summer of 1865. To keep the channel open, and avoid risks from sum-

mer freshets, a wooden pier and two trestle abutments 40 feet in height, were erected to support two spans of wooden Howe truss bridge, on which were placed wooden trestles 25 feet in height, to carry the iron superstructure of the channel span. The erection of the channel span occupied about three weeks. The entire work was completed in August, 1865, without accident.

The general design of the deck spans is similar to that of the channel span. The end posts are vertical. The upper chords consist of cast iron tubes to resist the compressive strains, with two lines of rolled I beams, one at each side of each tube, to sustain the floor timbers supporting the track.

The channel span was fitted in the shops of the Pennsylvania Railroad Company, Altoona.

The Keystone Bridge Company of Pittsburgh were the contractors for the manufacture and erection of the seven deck spans, and the erection of the channel span; also, at the same time, for the manufacture and erection of the great double track iron span of 265 feet over the Monongahela River at Pittsburgh, the long line of plate bridge in South Pittsburgh, and the iron bridge at Saw Mill Run, all for the same line of road. The channel span over the Monongahela was constructed from the patterns of the channel span at Steubenville, such modifications being made as were necessary to adapt the bridge for a double line of rails.

All these bridges have been constructed by the aid of the most approved machinery; the bearings being actually planned and the eyes in the eye bars of chords being drilled with so great accuracy that no variation exceeding 100th part of an inch was allowed. To test the strength of the large tubes, and the wrought iron bars, chords, &c., a hydrostatic testing machine was provided, capable of exerting a compressive force of 675 tons on columns 3 feet diameter and 30 feet in length, and a tensile strain of 180 tons on bars 40 feet in length, or on any intermediate size; thus enabling the engineer to test to the proof strain, all the materials used in these structures.

Owing to unavoidable delays in the preparation of this machine, it was possible to test only a few of the posts, chords, bars, &c., but the results demonstrated conclusively the accuracy of the data from which the proportions of the tubes had been determined.

The completed structure was tested by passing a train of engines and cars loaded to their utmost capacity with railway bars, the load

entirely covering the channel span, and amounting to about $1\frac{1}{2}$ tons per lineal foot. The deflection being carefully indicated by a pencil point on a rod fixed to the scaffolding, free from the structure, did not exceed five-eighths of an inch. The weight of cast iron in the channel span is greatly increased by the material consumed in the webs and ribs combining the twin chord tubes and posts, also in the additional system of transverse struts to resist the effects of the diagonal bracing. By combining the posts and chords in this manner, the effective width of each truss was increased to 45 inches, thus adding to the lateral stiffness of the posts and chords, and ensuring the lateral stability of the bridge. This system of combining and trussing the posts was new and untried. This span was the pioneer of long spans of iron truss bridges on this continent, and to ensure success it was deemed prudent to allow considerable margin on the side of safety.

The weight of cast iron consumed in the construction of the channel span was 2136 pounds per lineal foot, and of best refined wrought iron 1423 pounds per lineal foot.

The line was opened in September, 1865, and since that time the bridge has sustained the constant heavy traffic without developing any defects, or requiring adjustment.

Since the completion of this bridge, arrangements have been effected with the "Union Iron Mills" of Pittsburgh, to furnish the "Linville and Piper" patent wrought iron tubular columns, "Upset Chord Bars," and wrought iron beams for the patent upper chords, which are now generally adopted in the construction of long spans. They would have been employed in the Ohio River Bridge in preference to cast iron upper chords and columns, if delays in the preparation required to manufacture these shapes had not been apprehended.

Self-Registering Compass.—An instrument of this description, devised by Captain Albini, of the Italian Navy, and constructed by Messrs. Elliot Bros., of London, was exhibited at the late *Conversazione* of the Institute of Civil Engineers. It consists essentially of a compass, with a card carrying types at its periphery in such a way that, by an attached clockwork, an impression may be made at stated intervals on a band of paper, from whatever type is over a certain point at these times. Thus clearly an almost continuous record of the ship's course may be automatically produced.

STEAM BOILER EXPLOSIONS.

THERE is no subject upon which we have written more than that of steam boiler explosions. These occurrences are denominated "accidents," but long past experience has taught us that they almost invariably owe their origin to either faulty construction, bad working, or careless and inefficient tending. "Accident" is the convenient term under which steam users often obtain absolution from culpable carelessness, or even wilful and criminal neglect. As matters stand at present, boiler makers can palm off bad boilers on the public, and steam users employ them with the certainty that when they explode with fatal consequences they will, by the help of a coroner and his jury, be publicly absolved from all responsibility, and the event proclaimed to be "accidental." We have said frequently before, and we again repeat, that the causes of explosion are so simple, their results so fatal, and their occurrence so frequent, that it is high time some action was taken to secure common sense investigations into these matters. The Manchester Steam Users' Association has done very much, through their engineer, Mr. L. E. Fletcher, in exposing the fallacy of the present system of investigation. At the last annual general meeting of its members, as well as at the previous one, attention was called to the unsatisfactory character of the inquiries conducted by coroners with regard to fatal boiler explosions, and to the erroneous verdicts returned. It was also shown how important it was that this evil should be corrected, and sound information disseminated in every case, in order to check the loss of life and suffering at present recurring week by week, and at the same time render unnecessary any governmental action, which might prove an interference with the freedom of the steam user. With this view, resolutions were passed at both of those meetings, requesting the committee to take the necessary steps to secure these investigations being rendered more satisfactory, so that the truth might be fully arrived at and plainly spoken in every case. In order to place the matter prominently before the public, a paper upon the subject was read at the last meeting of the British Association. Following this, at the annual general meeting of the Steam Users' Association, held on March 9 last, it was proposed that the attention of the Government should now be drawn to the subject, and that a deputation should wait upon the Home Secretary with a memorial.

Thus far, this useful association had proposed. Now came the time to act; and we find that no time was lost in carrying out the proposition. At the following meeting of the Executive Committee, a memorial was submitted for approval, discussed and adopted. Mr. Thomas Bazley, M.P. for Manchester was at once communicated with, and his assistance in the matter requested; and through his good offices, a deputation of the Association had an interview with Mr. Bruce, the Secretary of State for the Home Department, on Friday, April 16. A sudden and severe attack of illness prevented Mr. Fairbairn, the President of the Association, accompanying the deputation. It consisted of three of the Vice-Presidents, Mr. Thomas Bazley, M.P., Manchester; Mr. Hugh Mason, Ashton-under-Lyne; and Mr. John Penn, C.E., Greenwich. Also of Mr. John Lancaster, M.P., Wigan; and Mr. Thomas Schofield, Manchester, members of the Executive Committee; as well as of Mr. John Hick, M.P., of Bolton, Corresponding Member, and Mr. L. E. Fletcher, Chief Engineer. Mr. Bazley introduced the deputation to the Home Secretary, and briefly called attention to the serious loss of life and suffering entailed by steam boiler explosions. He pointed out that this was preventable, and explained that it was the wish of the memorialists that coroners should be empowered and instructed to command the attendance of eminent engineers to give evidence, when conducting enquiries, in consequence of these sad disasters, so that the light might be thrown on the subject, and greater care induced; by which means, it was thought that the loss of life and property now occurring would be much lessened, if not altogether prevented. Mr. Bazley concluded by presenting Mr. Bruce with the memorial, which we shall now proceed to notice.

We have often had occasion to observe that it is entirely in the hands of steam users whether they will, by the exercise of common sense and ordinary discretion, save themselves from Government interference and control, or whether, by persistently pursuing a short-sighted and danger-fraught policy, they will continue to court that supervision which they would be the first to most strenuously resist. Nor would we wish to see such a system established. Nor does the Steam Users' Association desire this. On the contrary, the object the memorialists have in view is not to promote a system of Governmental periodical boiler inspection, to which manufacturers entertain a strong feeling of repugnance, and which the

Association was originally founded to prevent. But the object is to so improve coroners' inquiries with regard to boiler explosions, that sound views with regard to the causes of these disasters may be disseminated, and all mystery with regard to them dispelled. Boiler explosions would be prevented, and further Governmental interference would be rendered unnecessary, if only faithful investigation and plain speaking were made compulsory. And the way in which this is to be accomplished is clearly set forth in the memorial. That important document first points out the constant loss of life and the suffering arising from steam boiler explosions. At the present time, nearly fifty explosions occur on an average every year, killing from sixty to seventy persons, and injuring as many others. Many of the persons killed and injured are bread-winners, so that not only do they suffer, but a great many others are rendered more or less destitute. The number of persons killed every year by boiler explosions exceeds the number of passengers killed on all the railways throughout the United Kingdom. From the return published by the Board of Trade, it appears that during the last six years, 123 passengers were killed, while during the same period 390 persons were killed by boiler explosions, the annual average of lives lost being from twenty to twenty-one in the case of railway passengers, and of sixty-five in consequence of boiler explosions. Thus it will be seen that for every passenger who loses his life by railway travelling, three persons are killed by boiler explosions.

Such are the results. Now as to the cause; and this, as shown by the memorial, is summed up in one short word—neglect. The system of voluntary periodical boiler inspection carried out by the Association for the last fourteen years has proved fully adequate to the prevention of explosions; not a single boiler ever guaranteed has exploded. The constant investigations of boiler explosions have shown that much unnecessary mystery has been attached to the subject of steam boiler explosions, and that they all arise from the simplest causes, and could readily be prevented. As a rule, boilers burst simply because they are bad. Bad either from original malconstruction, or bad from the effects of hard work and old age. In a word, the cause of every boiler explosion is neglect, and the preventive simply care. It would follow that if people will have no care for themselves, no one ought to care for them. But the suffering does not always fall on the careless ones. Death is

dealt around amongst the innocent, whilst the guilty are generally absolved, even from blame. It is for and on behalf of the real sufferers that the Association interferes, and by the memorial shows coroners' investigations, with regard to steam boiler explosions, to be incomplete, and the verdicts delusive. It is not as an institution that the coroner's inquest is condemned, but it is the manner in which it is practically carried out to which the strictures in the memorial refer. The next point is, how this difficulty is to be met.

The plan recommended for adoption in the memorial is simply that every coroner should be both empowered and instructed, when conducting an inquiry consequent on a fatal steam boiler explosion, to avail himself of the assistance of two competent engineers, having no connection with the works at which the explosion occurred. These engineers are to visit the scene of the catastrophe, investigate the cause of the explosion, and report to the coroner thereon, their reports—which may be either joint or several, as most convenient—to be accompanied with explanatory sealed drawings, showing the original construction of the boiler, and, as far as possible the lines of rent, as well as the direction in which the fragments were thrown, and the distances at which they fell. The engineers to attend the inquest, and assist the coroner in his examination of witnesses, as well as to give evidence themselves before the jury. Further, in order to secure to the public the full advantage of the investigation, the engineers' reports, with the drawings, to be printed and deposited in the Patent Office, and to lie there for inspection and purchase, as in the case of specifications of inventions. Also copies of these reports to be forwarded to the members of both Houses of Parliament, as in the case of reports on railway accidents.

Such a course of procedure would primarily result in the accumulation of a mass of very valuable information. But beyond this—and what is of the highest importance—the responsibility of every steam boiler explosion would be brought home to the right party. This would render any further Governmental action unnecessary, and very shortly put an end to steam boiler explosions, simply by the force of truthful investigation and plain speaking. The fact is not lost sight of that many coroners have already the power—of which, in some cases, they avail themselves—of remunerating competent scientific witnesses, and which proves of considerable public service. But such is not the case in every instance, and coroners

to whom the plan proposed in the memorial has been mentioned, have stated that it would prove of considerable assistance to them in conducting their investigations on such technical subjects as boiler explosions, and that they should be glad to see it brought into operation.

In his reply to the memorial, Mr. Bruce appeared to fear that there might be some partiality in affording to boiler attendants a Governmental investigation on the occurrence of fatal disasters, without extending that protection to railway passengers and colliery workers. But it should be remembered that the very protection now sought for boiler attendants is already enjoyed by railway passengers and colliery workers, while the boiler attendant is left unbefriended, so that the partiality anticipated already exists to the neglect of the poor stoker, while the tendency of the Association's proposition would be, not to create a partiality, but to remove one already existing. The plan recommended is, in fact, simply an extension to boiler attendants of the privileges enjoyed by railway passengers and colliery workers, though in a slightly different form. In the event of a railway disaster, a Government engineer is sent down to make an investigation, and report to the Board of Trade thereon, his report being presented to the members of both Houses of Parliament, and open to the purchase of the public; while, in addition, he attends the coroners' inquest, and assists in the examination of witnesses. In the event of a colliery explosion, a Government mining inspector is present at the inquest, and assists the coroner in conducting his inquiry; while an annual return of colliery explosions is published. In the event, however, of a boiler explosion, though the subject is one of a technical character, and on which a good deal of misapprehension exists, while questions arise with regard to it which may fairly be considered as beyond the province of what is technically termed "common knowledge;" yet boiler attendants are left without the protection of a satisfactory investigation of the cause of the catastrophe, and evidence from incompetent parties, or from those interested in suppressing the facts, is accepted, and, consequently, as so often stated, the truth is seldom arrived at and seldom spoken.

It will be seen, from what we have stated, that some action is needed to redress the present inequality, and afford to boiler attendants the privilege of as unbiassed an investigation as is now secured by the Crown to colliery workers and railway passengers. The

initial movement in this action is now being taken by the Manchester Steam Users' Association, and should they succeed in bringing the measure they propose into operation, they will richly deserve the thanks of boiler attendants, boiler owners, and boiler makers. They will deserve the thanks of boiler attendants for saving the lives of some sixty or seventy of their number every year, many of whom are bread-winners, and by thus preventing a vast amount of suffering, not of themselves only, but also of their families. They will deserve the thanks of boiler owners and boiler makers for preserving them from a system of Governmental periodical inspection, to which sooner or later they would otherwise inevitably subject themselves, and which could not fail to be harrassing, and to limit progress. They will also deserve the thanks of the public for the additional security they will have imparted to life and property. We give them our cordial support in the matter, and our best wishes for their success.—*Mechanics' Magazine*.

ON THE BRIDGE OVER THE THAMES CARRYING THE WEST LONDON EXTENSION RAILWAY.*

BY MR. LAWFORD, M. INST. C. E.

THIS bridge was erected for the purpose of carrying the West London Extension Railway (which connects the North-Western and Great-Western Railways with Victoria Station, at Pimlico), across the River Thames, between Chelsea and Battersea, under the provisions of an Act of Parliament, which received the royal assent on August 13, 1859. The bridge consists of five segmental arches of wrought iron, each arch having a span 144 feet on the skew, with a rise of 16 feet, or $\frac{1}{3}$ th of the span. There are also, on the Middlesex side of the river, six, and on the Surrey side four, land arches of brick work, each with a span of 40 feet and a rise of 10 feet. The total length, therefore, of the whole structure is 1,270 feet. The abutments and piers of the five main openings are massive pieces of masonry, and are carried to a depth of 36 feet below Trinity high water mark, and 14 feet below the bed of the deepest part of the river. The soffit of the arches at the crown is 22 feet above the same point, *i. e.*, Trinity high-water mark, in accordance

* Abstract of paper read before the Civil and Mechanical Engineers' Society.

with the requirements of the Admiralty and the Conservators of the River Thames. The level of the rails is 26 feet above Trinity high-water mark. The width of the river between the two abutments is 776 feet on the skew, and 706 feet on the square. The width of waterway afforded is 720 feet. The angle at which the bridge crosses the river is 75 degrees. The greatest depth of water is 22 feet below Trinity high-water mark, the average rise and fall of the tides at this place being about 13 feet 6 inches.

The piers were constructed in coffer-dams, the inner row of piles being 5 feet from the outer edge of the lowest course of masonry, and were driven to a depth of 15 feet below the bed of the river; the outer row were 5 feet from the inner row, and were driven to a depth of only 8 feet from the same point, the space between the two rows of piles being filled with puddled clay. At the conclusion of the work the outer row of piles were drawn, but the inner row of piles were cut off level with the bed of the river. As the masonry of the piers proceeded, the space between them and the piles was filled with puddled clay, well trodden in, to a height of 3 feet above the bed of the river. Each pier stands on a bed of concrete 2 feet thick, extending 3 feet beyond the lowest course of footings. On the concrete is laid a course of York landings, 1 foot thick, and projecting 1 foot beyond the footings.

The foundations are carried up in a brick work to within 2 feet of the bed of the river, where there is a through course of stone 2 feet thick. From this point to the springing of the arch, the pier is faced with picked face ashlar of Bramley Fall stone. There is a second through course of stone half way between the bed of the river and the springing, and the upper, or last 7 feet of the piers, including the springers (which are 3 feet thick), are entirely solid stonework. The two abutments are built similarly to the piers, except that they have hollow chambers, filled with gravel to a height of 3 feet above the springing of the arch; each abutment being just on the edge of the river required only half a coffer dam for its construction. All stone work of both piers and abutments above springing height is tool dressed. The concrete used in this bridge was composed of five parts of gravel to one of blue lias lime, and the mortar of two measures of sharp sand to one of the same sort of lime.

Each of the river arches is composed of six wrought iron ribs, arranged in pairs, 2 feet 6 inches apart from centre to centre. The

arch or voussoir of the four main or inside girders is formed of $\frac{3}{8}$ inch vertical plates, 39 inches deep at the springing, and 24 inches deep at the crown, with double angle irons, each 4 inches by $3\frac{1}{2}$ inches by $\frac{1}{2}$ inch top and bottom, to which the flanges are attached by means of rivets. There is also a packing strip 8 inches by $\frac{1}{2}$ inch between the angle iron and the flanges. The flanges consist of two $\frac{5}{8}$ inch plates, 18 inches wide. The upper member of the inside ribs is a horizontal parallel girder, similarly constructed, but only 24 inches deep throughout its entire length. The vertical web is $\frac{1}{2}$ inch plate from the pier to the point where the upper and lower member intersect, *i. e.*, 15 feet from the centre of the arch, and from this point both vertical webs are $\frac{3}{8}$ inch in thickness. The bottom flange of the horizontal girder consists of one plate $16\frac{1}{2}$ inches wide by $\frac{1}{2}$ inch, two angle irons $3\frac{1}{2}$ inches by $3\frac{1}{2}$ inches by $\frac{1}{2}$ inch, and a packing strip 8 inches by $\frac{1}{2}$ inch. The upper flange is 15 inches wide, all other dimensions being the same as those of the lower flange; but the top plate is slightly curved inwards towards the rails. In the two outside ribs the voussoir is constructed as already described, but is 30 inches deep at the crown, and 39 inches at the springing. It may be as well to mention here that in these two girders, on the outside faces of the arch, all the rivets, excepting those in the angle irons, are countersunk, no cover plate either being visible at the joints. The whole centre web presents, therefore, the appearance of one smooth unbroken plate. This centre web is a $\frac{3}{8}$ inch plate, the two flanges are single $\frac{1}{2}$ inch plates 16 inches wide, the angle irons $3\frac{1}{2}$ inches by $3\frac{1}{2}$ inches by $\frac{1}{2}$ inch, and the packing pieces 8 inches by $\frac{1}{2}$ inch. The upper member is constructed in the same manner as that of the inside rib, but it has throughout the whole span $\frac{1}{2}$ inch vertical plates, and is only 18 inches deep at the crown of the arch. The upper flange is 18 inches wide, and is parallel with the lower flange, which is only 15 inches wide. The angle irons and packing pieces are of the same dimensions as those already described for the inside top members. The total depth of the girders, both inside and outside at the centre of the arch, is the same, *viz.*, 48 inches.

The sectional area of each of the four main girders is as follows: In the arch at the springing, 80 square inches; in the upper member do., 43 square inches—total, 123 square inches; and at the centre of the arch, where the upper and lower members are together, 105 square inches, the mean average being 114 square inches. These

are the full sectional areas, including the rivets. The voussoir and the upper horizontal girder of the four main girders are connected together by a lattice spandrel, composed of H-iron, of three different sizes, viz., 7 inch, 6 inch and 5 inch by $\frac{1}{2}$ inch. A stiffening bar of flat iron, $\frac{3}{8}$ inch thick, is added to each side of the H-iron, connecting the lattice bars throughout at the angles of intersection. In the outside girders the lattice and stiffening bars are all made of double T-iron, riveted together, thus $\frac{1}{2}$ inch, and of the same dimen-

sions as the H-iron, i. e., 7 inches by $3\frac{1}{2}$ inches, 6 inches by 3 inches, and 5 inches by $2\frac{1}{2}$ inches, all $\frac{1}{2}$ inch iron. Each pair of ribs is connected near the haunches by means of frames, composed of angle irons, cross braced and riveted to the ribs, forming an open box girder. This principle is continued to the crown of the arch, where the voussoir and top girder unite in a double cell. Each pair of main girders are braced together at the haunches by means of trellis transverse girders 2 feet 6 inches deep, carried up at equidistant intervals to within 10 feet of the centre of the arch. There are seven of these in each half arch; they are composed of angle and bar iron, $3\frac{1}{2}$ inches by $3\frac{1}{2}$ inches by $\frac{1}{2}$ inch. The top members of the main ribs are secured together by the cross girders, which carry the roadway; they are fixed over the whole length of the bridge, 4 feet apart from centre to centre, and are composed of a middle web of iron, 10 inches deep, and $\frac{1}{2}$ inch thick, the bottom of which is flanged with double angle iron, $3\frac{1}{2}$ inches by $8\frac{1}{2}$ inches by $\frac{1}{2}$ inch, and the top with double channel iron, on the lower flange of which the buckle plate flooring rests. The cross girders rest on the lower flange of top main girder, and are secured in their places by iron knee-pieces, riveted through the centre webs. The main or bearing girders are again cross braced by diagonal rods, bolted to a centre plate, and to brackets riveted on to each of the angles. There are three sets of these tie-rods in each half arch.

Upon the end of each arch or voussoir a plate of cast iron, 3 inches thick is fixed, the back of which is planed quite true and even. These, again, fit into heavy cast iron shoes (weighing 2 tons each), let into the stone skewbacks of the piers and abutments, and by means of wrought iron wedges are finally adjusted in their seats. Contraction and expansion are provided for as follows: Cast iron standards are bolted to the stone work of the piers and united by a cast iron frame, secured with bolts and nuts. These standards have

recesses to receive the ends of the horizontal girders, and secure them in position, at the same time allow for horizontal motion. A bed and bearing plate, planed perfectly parallel, are fixed under the ends of the horizontal girders, upon which they slide.

The railway is a double line of mixed gauge, and is carried over the bridge by means of longitudinal timbers with transoms every 10 feet. Ash ballast is used all over the bridge. A cast iron moulding is attached to the horizontal girder, throughout its whole length, and a cast iron plinth is bolted on to the top of the same; an ornamental cast iron parapet is fixed on the plinth, and the whole is surrounded by a wooden hand rail. The iron of which this bridge is built was manufactured by the Shelton Iron Company, at Stoke-upon-Trent, and is, perhaps, better known as Lord Granville's iron. In the experiments made for testing the quality of the iron, it bore a tensile strain of nearly 18 tons per square inch, without showing any signs of fracture. The H and T-iron used in the spandrels was rolled by the Butterley Iron Company. About three-quarters of the iron work was made and put together by Messrs. Calvert, of York, and, on the collapse of that firm, it was completed by Mr. Charles Lungley, the iron ship builder of Deptford. The contractor for the work, and, indeed, for the whole of the West London Extension Railway, were Messrs. Brassey and Ogilvie—names well known in the railway world—and a sufficient guarantee that the work would be well and substantially carried out. The width of the bridge between the cast iron parapets is 30 feet in the clear. The total width of the piers from out to out above springing level is 35 feet 6 inches, and at that level, including the cut waters, 53 feet 6 inches. The total cost of the bridge was £104,000, or £82 per lineal foot, and £2 10s. per superficial foot. The materials used in its construction were 2,000 cubic yards of concrete, 11,100 cubic yards of brick work in mortar, 130,000 cubic feet of stone, 2,160 tons of wrought iron, 366 tons of cast iron, 2 tons of lead, and 28,000 cubic feet of timber, exclusive of the piles. This bridge was the joint design of Messrs. Baker and Bertram, the chief engineers of the Great Western and North-Western Railways. It was opened for public traffic on March 2, 1863, since which date some hundreds of trains have passed over it daily, and I am not aware that, up to the present time, any expense whatever (beyond the maintenance of the road) has been incurred, either in repairs or otherwise. The bridge was only 15 months under con-

struction, *i. e.*, from the time the first stone was laid until a locomotive passed over the river. The bridge was very severely tested on January 7, 1863, by Captain Tyler. The narrow gauge load consisted of two locomotives and tenders, funnel to funnel, and two tank engines; total length of train 132 feet, total weight 176 tons. The broad gauge load consisted of two tank engines, in the same position as the narrow gauge engines, each drawing six loaded coal wagons; total length of train 276 feet, total load 292 tons; these two loads, collectively, being equal to about $2\frac{1}{2}$ tons per lineal foot. First, the narrow gauge load passed over No. 1 arch at speed, the deflection 5-100ths of a foot. Second, the broad gauge load passed at speed—same result. Third, the broad gauge load on one road and narrow gauge on the other, both passed together over No. 2 arch at speed. On going over No. 1 arch, No. 2 rose 3-100ths of a foot. On going over No. 2 it deflected nearly 10-100ths of a foot, rise and fall 13-100ths of a foot. Fourth, both loads were brought to rest on No. 2 arch, deflection 11-100ths of a foot. When the loads passed slowly over No. 3 arch, No. 2 rose 2-100ths of a foot, rise and fall 13-100ths of a foot. Both loads remained stationary for some time on this arch, but no further deflection took place, and, with the removal of the load, the girders rose simultaneously to their original height. Fifth, the same thing was done on No. 3 arch with a precisely similar result. Sixth, the same experiment was made on the fourth arch, and in exactly the same manner as the fourth experiment—rise of arch 2-100ths of a foot, deflection 10-100ths of a foot, rise and fall 12-100ths of a foot. Seventh, the same thing was done on the fifth arch; the rise was 2-100ths of a foot, deflection 8-100ths of a foot, rise and fall 10-100ths of a foot. The bridge was very steady throughout these experiments, and there was very little lateral vibration, even when both loads passed at the same time in the same direction, either slowly or at speed.

Hair Springs for Watches.—A striking instance of the immense value a small piece of steel may acquire by the great power of skilled mechanical labor, is the balance-spring of a watch. From its extreme fineness and delicacy, 4,000 weigh not more than one ounce, and exceed in value \$5000.

BELTING FACTS AND FIGURES.

By J. H. COOPER.

(Continued from page 27.)

FROM a circular issued by P. V. H. Van Riper, of Paterson, N. J., we select the following:—

"Having been engaged in the manufacture of Oak Leather Belting for the past fifteen years, I would respectfully call attention to the essential points necessary to the manufacture of good belting, the first of which is the selection of the leather, which should be *oak tanned*, it being more pliable than any other, and as durability is required, it should be thoroughly tanned and made from young hides, they having more strength than the hides from old animals.

"Suitable leather having been chosen, though it may be ever so good, may be spoiled in currying, and as this is an important part, it is conducted under my own supervision, where I have the *shoulders* cut from the hides, and nothing but *FOUR feet in length of the choice butts*, curried for belting purposes, as the *shoulder naturally stretching in a different direction* from the butts, causes that great annoyance in factories of belts running crooked.

"The putting on of belts should be done by a person acquainted with the use of belting, and too much judgment cannot be exercised in this respect, as the wear of the belt depends considerably on the manner in which it is put on, therefore, the following suggestions, if practiced, will be of much service to persons employed in this capacity. The butts to be joined together, should be cut perfectly square with the belt, in order that one side of the band may not be drawn tighter than the other. For the joining of belts, good Lace Leather, if properly used, being soft and pliable, will always give better satisfaction than any patent fastening or hooks which have yet been invented.

"Where belts run vertically, they should always be drawn moderately tight, or the weight of the belt will not allow it to adhere closely to the lower pulley, but in all other cases they should be slack.

"In many instances, the tearing out of lace-holes, is often unjustly attributed to poor belting, when in reality, the fault lies in having a belt too short, and trying to force it together by lacing, and the

more the leather has been stretched while being manufactured, the more liable it is to be complained of.

"All leather belting should occasionally be greased with the following mixture, or it will become dry and will not adhere to the pulleys: one gallon neats foot or tanners' oil, one gallon tallow, twelve ounces resin, dissolved by heat, and well mixed together, to be used cold, the belt having been previously dampened with warm water, except where it is spliced together. During the winter season, an extra quantity of oil should be added to the mixture.

"To obtain the greatest amount of power from belts, *the pulleys should be covered with leather*, this will allow the belts to be run very *slack*, and give twenty-five per cent. more wear. I drive a large circular saw, requiring fifteen horse-power, with a very slack belt, the pulleys being *covered with leather*.

"For heavy counter belts not intended to be used on cone pulleys, or at half cross, I recommend double belts made from shoulders only, which I furnish at the price of single belting, and as the *stretch is taken out of the shoulders after they are cut from the side*, they are guaranteed to give better satisfaction as a counter belt, than a single belt will.

"More power can be obtained from using the grain side of a belt to the pulley than from the flesh side, as the belt adheres more closely to the pulley; but there is this about it, the belt will not last half so long, for when the grain, which is very thin, is worn off, the substance of the belt is gone, and it then quickly gives out; so that I would advise the more saving plan of obtaining power by driving with wider belts, and covering the pulleys with leather.

"Where belts are to run in very damp places, or exposed to the weather, I would recommend the use of rubber belting; but for ordinary use it will not give the satisfaction which is so generally obtained from using oak leather belting, as it cannot be run on cone pulleys through forks, or at half cross, and with fair usage would be worn out, while a leather belt was regularly performing the work allotted to it; for when the edge becomes worn, the belt soon gives out."

We formularize the following rules from the text:—

$$H P = \frac{3 w c v}{16000}$$

$$W = \frac{16000 H P}{3 c v}$$

In which H P = number of horse-power transmitted.

w = width of belt in inches.

c = belt contact with smaller pulley in lineal feet.

v = velocity of belt in feet per minute.

The following examples are given: "A $18\frac{1}{4}$ -inch belt, running at the rate of 1600 feet per minute, over a 4 feet pulley, and touching 5 feet of its circumference, gives 20 horse-power." This is equal to 888.88 square feet of belt per minute, per horse-power.

"A 20-inch belt at 2000 feet per minute, on 6 feet of the circumference of a 4 foot pulley, gives 45 horse-power." This is equal to 74.074 square feet of belt per minute per horse-power. ●

From an article in *Appleton's American Cyclopaedia*, we take the following:—

"Belts are used instead of gearing, when the shafts to be connected are far apart.

"Belts in general are used between parallel shafts, and when the direction of motion is desired to be reversed, the belt is crossed.

"The diameters of belt pulleys are in the inverse ratio of their speeds.

"To modify the velocity while in motion, conical drums are employed on parallel shafts, with the cones reversed in position, and a shifter used to move the belt and hold it in any desired position.

"When shafts are not parallel, but are in the same plane, the only way to connect them by belts, is to use a third shaft placed across both, and at equal angles, or nearly so, with each, and to which each is connected by a belt.

"When shafts are neither parallel nor in the same plane, they can be connected by a belt, but there is only one place on the shafts for the pulleys. These must be at the ends of a straight line perpendicular at the same time to both axes. There is only one such line. This theoretical place has to be corrected in each particular case, according to the diameters of the pulleys, by taking care that the belt arrives square on each pulley, no matter how obliquely it leaves the other.

"As a consequence of this unavoidable connection, the motion of the shafts cannot be reversed without securing the pulleys in other places.

"A careful attendant will make a belt last five years, which through neglect, might not last one.

"It has been found in practice, that belts must not be run faster

than 30 feet per second, nor have a tension of above 300 pounds per square inch of section.

"The friction of a belt is double on wood what it is on cast iron.

"If a belt is passed over a horizontal cylinder with a known weight suspended at one end, and a spring balance attached to the other, and gradually let go until the belt begins to slide, the suspended weight *minus* the weight indicated by the balance, is the friction.

"It has been found that by taking a turn and a half around a rough cylindrical post, 1 pound will hold 110 pounds in check, and that by taking $2\frac{1}{2}$ turns, 1 pound will hold 2500 pounds.

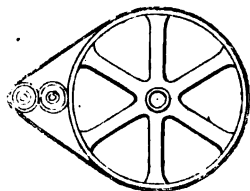
"A 12 inch belt over a 4 feet pulley at 30 feet per second, will transmit the power of a 6-inch cylinder engine having 12-inch stroke, running 125 revolutions per minute, under 60 pounds of steam."

If we allow 30 pounds average pressure per square inch on piston, this engine will give 6.4 HP., and the data above, 281.25 square feet of belt per HP. per minute, which is a liberal allowance. See example No. 12, in first article.

"Where pulleys of very unequal diameter are coupled by a belt, the surface of contact with the smaller pulley is so little that the belt must be very tightly stretched in order to transmit its full duty. This is especially the case where the two pulleys are very near each other. In the case of the small centrifugal pumps, made by Gwynne & Co., for plantation and farm use, the horse gear is connected with the pump by belting from a large pulley to the riggers of the pump, the relative diameters of the two being about as 6:1, while also they are placed but four or five inches apart. The short belt, thus acting upon a very small portion of the surface of the rigger, requires to be very tightly stretched, and in this way a heavy strain is brought upon the bearings. To relieve this strain, Messrs. Gwynne & Co., place a friction wheel between the pulley and rigger, so as to touch both in a line connecting their centres. This wheel, revolving freely upon a fixed center, receives the strain exerted by the belt. No means of adjustment are provided to compensate for the wear of the journals, nor is such provision believed to be necessary. The arrangement, so simple in itself, appears to possess a considerable advantage over the ordinary practice of throwing the whole strain of the belt upon the bearings."

"The intermediate pulley is recessed in the centre of its face, so as to bear on the others at the edges only. The arrangement is said to work well, and is here shown.

"A leather belt, $19\frac{1}{2}$ inches wide, is driven by a drum 11 feet in diameter, having iron arms and wooden lagging, and making 92 revolutions per minute; consequently, the belt moves at the rate of 3179 feet per minute. The amount of power transmitted by this belt is estimated at 175 horse-power, corresponding to a tension of the tight side



of the belt of not less than $\frac{175 \times 33,000}{3179} = 1817$ pounds. The pulley driven by the belt is 6 feet in diameter, and is entirely of iron; the peripheries of both drum and pulley are covered with leather. The belt is made of two thicknesses of leather cemented together, and is about $\frac{3}{8}$ inch thick; it was slightly greased on the inside with a mixture of tallow and neats-foot oil. The slack side running upwards nearly vertically."

The data above give 29.5 square feet of belt per minute, per horse-power, and a tension of 93.18 pounds per inch wide.

Rule for ascertaining the horse-power of belts, by Mr. F. W. Bacon, of New York, from *Sci. Am.*, July 17, 1869, p. 35. We convert the text into the following:—

$$\frac{HP \ 6000}{v \ c} = w.$$

In which HP = horse-power transmitted.

v = velocity of belt in feet per minute.

c = contact of belt with smaller pulley in lineal feet.

w = width of belt in inches.

PUMPING ENGINES.

By H. P. M. BIRKINBINE, C. E.

THE article on "Pumping Engines," in the May number of the *Journal*, page 323, has been replied to by one of the makers of the direct-acting duplex short-stroke pumping engine, in a letter published in the June number of the *Journal*, page 425.

It was not necessary for any one to personally apply the remarks in the closing paragraph; they were general, and their truth cannot be denied. The complaint that the "spirit of the article" is "detractive and unjust," and the presentation of a table, arranged to suit the purpose, is no answer to the article. Little importance can be attached to tables, certificates and statements when prepared and presented by interested parties. It would have been far more satisfactory and useful, if some one of those interested in this form of pumping engine, would reply to that portion of the article which "deals with the principles upon which the engine is constructed," instead of complaining of the "spirit." It is *pumps*, not *persons*, which are to be discussed.

The article has certainly had one good effect. It has reduced the duty claimed for these pumping engines from 1,300,000 foot-pounds to 473,328 foot-pounds,—from the regions of impossibility, to those of possibility.

From a personal observation of several of these engines, and a careful analysis of the working, for the past two years, of a large one furnishing water to a city, I am satisfied that the duty given in the article, (200,000 foot-pounds) is large and ample.

It is to be hoped that the "unjust" statements in the article will be exposed, and the means given by which the extraordinary results claimed for this form of engine are produced. Until such information is imparted, the public cannot be expected to accept any mere statements of duty, however wonderful they may appear.

In physics, supernatural means are never estimated, but some arrangement is looked for in accordance with well known laws, to produce results.

When a machine is defective in its proportions or arrangements, low results are the consequence. As the pumping engine is the machine by which the power of the steam of the boiler is applied to force the water, any defect in its arrangement or proportions will result in a waste of steam, and, necessarily, of fuel, and, as a consequence, the duty will be low, whoever the maker may be, or by what name it may be called, or how many patents may be concentrated upon it. If the duplex direct-acting short-stroke engines are thus defective, as I endeavored in my former article to show, then the low duties are inevitable.

A Cornish engine is now running which produces a lower duty than a double-acting high-pressure fly-wheel engine used in the

same works illustrating defects in construction. The cost of fuel used by the different engines pumping water for supplying London, varies from .075 pence to .543 pence per million foot-pounds.

As the engines for which these extraordinary high duties are claimed are covered by one or more patents, there is no necessity for secrecy. By no other means can they so readily be brought into notice as by a thorough and candid discussion of their peculiarities.

A SYPHON FOR DRAINING A TUNNEL.

BY COL. CLAUDIUS CROZET, C. E.

MR. EDITOR:—I hand you this paper for insertion in your *Journal* if you consider it of sufficient interest. It was given to me many years ago by my friend the late Col. Crozet himself. The Colonel had at one time held the distinguished position of superintendent of the U. S. Military Academy at West Point; and subsequently was Chief Engineer of the work alluded to in the paper.

Yours respectfully,

JOHN C. TRAUTWINE.

The tunnel through the Blue Ridge, in Virginia, is 4,273 feet long, and 700 feet below the top of the mountain; on this account it was thought expedient to construct without shafts. This tunnel slopes from west to east, at the rate of 70 feet to the mile, so that, on the west side, the water, which proved very abundant and troublesome, had to be removed by artificial means. For some distance at the entrance, I determined to introduce a syphon of unusual length, which proved a difficult and, at the same time, interesting experiment.

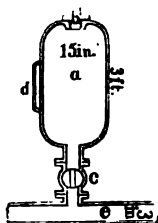
The whole length of the syphon is 1,792 feet, viz: 563 feet inside of the tunnel, and 1,229 feet outside. The level of the water inside is upwards of 9 feet below the summit, and the fall outside $29\frac{1}{4}$ feet, so that the head is a fraction over 20 feet.

Iron faucet pipes of 3 inches interior diameter were adopted. It was feared that larger ones would carry along too much air; and that the syphon would have to be fed too often at the summit, an apprehension which the results observed seem to justify.

A common faucet cock is placed at each end, to close the syphon when it becomes necessary to fill it again with water; and at the

summit a large air vessel is provided to collect the air disengaged from the water, with a suitable opening at top, to let the air out and replace it with water; this opening being closed by a cap tightly screwed down. At the bottom of the air vessel, there is besides a large cock, which is closed while the syphon is being fed through the top opening, so as not to interrupt the running of the syphon during the operation.

The annexed diagram represents the air vessel *a*; *b* is the cap; *c* the cut-off cock; *e* the main pipe or syphon; *d* is a glass tube for observing the level of the water. This, however, being often broken was dispensed with at last; the level of the water being easily ascertained by knocking against the air-vessel.



Things being now disposed as described, it might be supposed that the discharge would have gone on uninterruptedly, requiring only a careful attention to replenish occasionally with water the air vessel; but such was not the case; at first the joints had been made tight by packing with oakum and then thickly pitched over. The syphon was filled with water through the air-vessel, which being then closed and the ends open, the water began to flow; but this did not continue for more than five or ten minutes, when the air vessel was found empty of water, and had to be replenished at these short intervals; moreover, notwithstanding this tedious repetition of feeding the syphon, it would ultimately run dry in about two hours.

This was a truly discouraging circumstance; we ascribed it to the fact that, there being upwards of 200 joints, air was introduced in small bubbles through the oakum packing by the external pressure at every joint, and that it accumulated rapidly all along, especially in the longer arm of the syphon which soon became too light. Accordingly, we decided not to abandon the enterprise, but to caulk the joints with lead in the usual way, which was not done before for motives of economy, and because, it being only a temporary fixture, it would have been more easily taken apart.

This operation was not yet entirely successful, though the caulking was made so hard that many of the bells broke in packing, without making the joints perfectly impermeable. Then a cement was made of equal parts of white lead and red lead mixed to the consistency of soft putty, with equal quantities of Japan varnish and boiled linseed oil. This cement, carefully coated over the joints, made them at last perfectly tight. The syphon thus improved runs

now regularly. Still the air vessel must be replenished with water every two hours, which is done by a pipe leading from a spring, and, moreover, every six hours the ends must be closed, and the whole syphon filled in anew with water; otherwise it would run dry.* It is probable that, owing to its being so long, and consequently so level, bubbles of air travel along very slowly and increase in size gradually; possibly some air may find its way under external pressure through the iron itself.

A curious circumstance took place in the beginning: The tunnel having progressed much beyond the well of the syphon, and the water considerably increased, a horse-power with chain pumps was constructed at the farther end to pump up the water into troughs, by which it is led to the syphon well. Here, the syphon being insufficient for this accession of water, another horse-power was introduced to pump up water out of the same well. As soon, however, as the chain pumps began to revolve in the well, the syphon suddenly stopped and we were obliged to dig a separate well for it; since which time both have worked well.

The syphon, by actual measurement, when just replenished, discharges $48\frac{1}{2}$ gallons per minute, whereas all known formulæ give between 54 and 60 gallons, and furthermore in Weale's *Engineers' and Contractors' Companion* occurs this conflicting remark taken from R. A. Peacocke's work:

"By Dr. Young's formula (considered by him the best)—

A 5-inch pipe would be used where a $3\frac{1}{2}$ would suffice.

7	"	"	"	"	5	"
10	"	"	"	"	7	"
14	"	"	"	"	10	"

and then he goes on to show the useless expenditure resulting from pipes too large being used in obedience to these formulæ. But here in this extraordinarily long syphon, his opinion is not sustained, and we find, on the contrary, the discharge is less than the formulæ give; and that neither they nor Mr. Peacocke's rules are applicable to this case.

The syphon I have described is, I believe, the longest ever attempted to be used, and on this account the results and anomalies it presents are somewhat interesting. It certainly has rendered considerable service in the Blue Ridge Tunnel; with no other current expense than the employment of a man to attend to the air vessel.

* Would not this be remedied by making the air vessel *self-acting* like the air valves sometimes used on water mains?—J. C. T.

Mechanics, Physics, and Chemistry.

ON THE BLUE COLOR OF THE SKY, THE POLARIZATION OF SKY-LIGHT, AND POLARIZATION OF LIGHT BY CLOUDY MATTER GENERALLY.

BY JOHN TYNDALL, L.L.D., F.R.S.

(Concluded from page 40.)

BUT, as regards the polarization of the sky, we know that not only is the direction of maximum polarization at right angles to the track of the solar beams, but that at certain angular distances, probably variable ones, from the sun, "neutral points," or points, of no polarization exist, on both sides of which the planes of atmospheric polarization are at right angles to each other.

I have made various observations upon this subject which I reserve for the present; but pending the more complete examination of the question the following facts and observations bearing upon it are submitted to the Royal Society.

The parallel beam employed in these experiments tracked its way through the laboratory air exactly as sun-beams are seen to do in the dusty air of London. I have reason to believe that a great portion of the matter thus floating in the laboratory air consists of organic germs, which are capable of imparting a perceptibly bluish tint to the air. This air showed, though far less vividly, all the effects of polarization obtained with the incipient clouds. The light discharged laterally from the track of the illuminating beam was polarized, though not perfectly, the direction of maximum polarization being at right angles to the beam.

The horizontal column of air thus illuminated was 18 feet long, and could therefore be looked at very obliquely without any disturbance from a solid envelope. At all points of the beam throughout its entire length the light emitted normally was in the same state of polarization. Keeping the positions of the Nicol and the selenite constant, the same colors were observed throughout the entire beam when the line of vision was perpendicular to its length.

I then placed myself near the end of the beam as it issued from the electric lamp, and looking through the Nicol and selenite more and more obliquely at the beam, observed the colors fading until

they disappeared. Augmenting the obliquity, the colors appeared once more, *but they were now complementary to the former ones.*

Hence this beam, like the sky, exhibited its neutral point, at opposite sides of which the light was polarized in planes at right angles to each other.

Thinking that the action observed in the laboratory might be caused in some way by the vaporous fumes diffused in its air, I had a battery and an electric lamp carried to a room at the top of the Royal Institution. The track of the beam was seen very finely in the air of this room, a length of 14 or 15 feet being attainable. This beam exhibited all the effects observed with the beam in the laboratory. Even the uncondensed electric light falling on the floating matter showed, though faintly, the effects of polarization.*

When the air was so sifted as to entirely remove the visible floating matter, it no longer exerted any sensible action upon the light, but behaved like a vacuum.

I had varied and confirmed in many ways those experiments on neutral points, operating upon the fumes of chloride of ammonium, the smoke of brown paper, and tobacco smoke, when my attention was drawn by Sir Charles Wheatstone to an important observation communicated to the Paris Academy, in 1860, by Professor Govi, of Turin.† His observations on the light of comets had led M. Govi to examine a beam of light sent through a room in which was diffused the smoke of incense. He also operated on tobacco smoke. His first brief communication stated the fact of polarization by such smoke, but in his second communication he announced the discovery of a neutral point in the beam, at the opposite sides of which the light was polarized in planes at right angles to each other.

But unlike my observations on the laboratory air, and unlike the action of the sky, the direction of maximum polarization in M. Govi's experiment enclosed a very small angle with the axis of the illuminating beam. The question was left in this condition, and I am not aware that M. Govi or any other investigator has pursued it further.

I had noticed, as before stated, that as the clouds formed in the experimental tube became denser, the polarization of the light discharged at right angles to the beam became weaker, the direction

* I hope to try Alpine air next summer.

† *Comptes Rendus*, tome li. pp. 360 and 369.

of maximum polarization becoming oblique to the beam. Experiments on the fumes of chloride of ammonium gave me also reason to suspect that the position of the neutral point *was not constant*, but that it varied with the density of the illuminated fumes.

The examination of these questions led to the following new and remarkable results:—The laboratory being well filled with the fumes of incense, and sufficient time being allowed for their uniform diffusion, the electric beam was sent through the smoke. From the track of the beam polarized light was discharged, but the direction of maximum polarization, instead of being alone the normal, now enclosed an angle of 12° or 13° with the axis of the beam.

A neutral point, with complementary effects at opposite sides of it, was also exhibited by the beam. The angle enclosed by the axis of the beam, and a line drawn from the neutral point to the observer's eye, measured in the first instance 66° .

The windows of the laboratory were now opened for some minutes, a portion of the incense smoke being permitted to escape. On again darkening the room and turning on the beam, the line of vision to the neutral point was found to enclose with the axis of the beam an angle of 63° .

The windows were again opened for a few minutes, more of the smoke being permitted to escape. Measured as before the angle referred to was found to be 54° .

This process was repeated three additional times; the neutral point was found to recede lower and lower down the beam, the angle between a line drawn from the eye to the neutral point and the axis of the beam falling successively from 54° to 49° , 43° and 33° .

The distances, roughly measured, of the neutral point from the lamp, corresponding to the foregoing series of observations, were these:

1st observation	2 feet,	2 inches.
2d	2 "	6 "
3d	2 "	10 "
4th	3 "	2 "
5th	3 "	7 "
6th	4 "	6 "

At the end of this series of experiments the direction of maximum polarization had again become normal to the beam.

The laboratory was next filled with the fumes of gunpowder. In

five successive experiments, corresponding to five different densities of the gunpowder smoke, the angles enclosed between the line of vision to the neutral point and the axis of the beam were 63° , 50° , 47° , 42° and 38° , respectively.

After the clouds of gunpowder had cleared away the laboratory was filled with the fumes of common resin, rendered so dense as to be very irritating to my lungs. The direction of maximum polarization enclosed in this case an angle of 12° , or thereabouts, with the axis of the beam. Looked at, as in the former instances, from a position near the electric lamp *no neutral point* was observed throughout the entire extent of the beam.

When this beam was looked at normally through the selenite and Nicol, the ring system, though not brilliant, was distinct. Keeping the eye upon the plate of selenite and the line of vision normal, the windows were opened, the blinds remaining undrawn. The resinous fumes slowly diminished, and as they did so the ring system became paler. It finally disappeared. Continuing to look along the perpendicular, the rings revived, but now the colors were complementary to the former ones. *The neutral point had passed me in its motion down the beam consequent upon the attenuation of the fumes of resin.*

In the fumes of chloride of ammonium substantially the same results were obtained as those just described. Sufficient, I think, has been here stated to illustrate the variability of the position of the neutral point. The explanation of the results will probably give new work to the undulatory theory.*

Before quitting the question of the reversal of the polarization by cloudy matter, I will make one or two additional observations. Some of the clouds formed in the experiments on the chemical action of light are astonishing as to form. The experimental tube is often divided into segments of dense cloud, separated from each other by nodes of finer matter. Looked at normally, as many as four reversals of the plane of polarization have been found in the tube in passing from node to segment, and from segment to node. With the fumes diffused in the laboratory, on the contrary, there was no change in the polarization along the normal, for here the necessary differences of cloud-texture did not exist.

* Brewster has proved the variability of the position of the neutral point for skylight with the sun's altitude. Is not the proximate cause of this revealed by the foregoing experiments?

Further. By a puff of tobacco smoke or of condensed steam blown into the illuminated beam, the brilliancy of the colors may be greatly augmented. But with different clouds two different effects are produced. For example, let the ring system observed in the common air be brought to its maximum strength, and then let an attenuated cloud of chloride of ammonium be thrown into the beam at the point looked at; the ring system flashes out with augmented brilliancy, and the character of the polarization remains unchanged. This is also the case when phosphorus or sulphur is burned underneath the beam, so as to cause the fine particles of phosphoric acid or of sulphur to rise into the light. With the sulphur fumes the brilliancy of the colors is exceedingly intensified; but in none of these cases is there any change in the character of the polarization.

But when a puff of aqueous cloud, or of the fumes of hydrochloric acid, hydriodic acid or nitric acid is thrown into the beam, there is a complete reversal of the selenite tints. Each of these clouds twists the plane of polarization 90° . On these and kindred points. experiments are still in progress.*

The idea that the color of the sky is due to the action of finely divided matter, rendering the atmosphere a turbid medium, through which we look at the darkness of space, dates as far back as Leonardo da Vinci. Newton conceived the color to be due to exceedingly small water particles acting as thin plates. Goethe's experiments, in connection with this subject, are well known and exceedingly instructive. One very striking observation of Goethe's referred to what is technically called "chill" by painters, which is due no doubt to extremely fine varnish particles interposed between the eye and a dark background. Clausius, in two very able memoirs, endeavored to connect the colors of the sky with suspended water-vesicles, and to show that the important observations of Forbes on condensing steam could also be thus accounted for. Brücke's experiments on precipitated mastic were referred to in my last abstract. Helmholtz has ascribed the blueness of the eyes to the action of suspended particles. In an article written nearly nine years ago by myself,

* Sir John Herschel has suggested to me that this change of the polarization from positive to negative may indicate a change from polarization by reflection to polarization by refraction. This thought repeatedly occurred to me while looking at the effects; but it will require much following up before it emerges into clearness.

the colors of the peat smoke of the cabins of Killarney* and the colors of the sky were referred to one and the same cause, while a chapter of the "Glaciers of the Alps," published in 1860, is also devoted to this question. Roscoe, in connection with his truly beautiful experiments on the photographic power of sky-light, has also given various instances of the production of color by suspended particles. In the foregoing experiments the azure was produced in air, and exhibited a depth and purity far surpassing anything that I have ever seen in mote-filled liquids. Its polarization, moreover, was perfect.

In his experiments on fluorescence Professor Stokes had continually to separate the light reflected from the motes suspended in his liquids, the action of which he named "false dispersion," from the fluorescent light of the same liquids, which he ascribed to "true dispersion." In fact it is hardly possible to obtain a liquid without motes, which polarize by reflection the light falling upon them, truly dispersed light being unpolarized. At p. 530 of his celebrated memoir "On the Change of the Refrangibility of Light," Prof. Stokes adduces some significant facts, and makes some noteworthy remarks, which bear upon our present subject. He notices more particularly a specimen of plate glass which, seen by reflected light, exhibited a blue which was exceedingly like an effect of fluorescence, but which, when properly examined, was found to be an instance of false dispersion "It often struck me," he writes, "while engaged in these observations, that when the beam had a continuous appearance, the polarization was more nearly perfect than when it was sparkling, so as to force on the mind the conviction that it arose merely from motes.† Indeed, in the former case the polarization has often appeared perfect, or all but perfect. It is possible that this may in some measure have been due to the circumstance, that when a given quantity of light is diminished in a given ratio, the illumination is perceived with more difficulty when the light is

* I have sometimes quenched almost completely, by a Nicol, the light discharged normally from burning leaves in Hyde Park. The blue smoke from the *ignited end* of a cigar polarizes also, but not perfectly.

† The azure may be produced in the midst of a field of motes. By turning the Nicol, the interstitial blue may be completely quenched, the shining, and apparently unaffected motes, remaining masters of the field. A blue cloud, moreover, may be precipitated in the midst of the azure. An aqueous cloud thus precipitated reverses the polarization; but on the melting away of the cloud the azure and its polarization remain behind.

diffused uniformly, than when it is spread over the same space, but collected into specks. Be this as it may, there was at least no tendency observed towards polarization in a plane perpendicular to the plane of reflection, when the suspended particles became finer, and therefore the beam more nearly continuous."

Through the courtesy of its owner, I have been permitted to see and to experiment with the piece of plate glass above referred to. Placed in front of the electric lamp, whether edgewise or transversely, it discharges bluish polarized light laterally, the color being by no means a bad imitation of the blue of the sky.

Prof. Stokes considers that this deportment may be invoked to decide the question of the direction of the vibrations of polarized light. On this point I would say, if it can be demonstrated that when the particles are small in comparison to the length of a wave of light, the vibrations of a ray reflected by such particles cannot be perpendicular to the vibrations of the incident light; then assuredly the experiments recorded in the foregoing communication decide the question in favor of Fresnel's assumption.

As stated above, almost all liquids have motes in them sufficiently numerous to polarize sensibly the light, and very beautiful effects may be obtained by simple artificial devices. When, for example, a cell of distilled water is placed in front of the electric lamp, and a slice of the beam is permitted to pass through it, scarcely any polarized light is discharged, and scarcely any color produced with a plate of selenite. But while the beam is passing through it, if a bit of soap be agitated in the water above the beam, the moment the infinitesimal particles reach the beam the liquid sends forth laterally almost perfectly polarized light; and if the selenite be employed, vivid colors flash into existence. A still more brilliant result is obtained with mastic dissolved in a great excess of alcohol.

The selenite rings constitute an extremely delicate test as to the quantity of motes in a liquid. Commencing with distilled water, for example, a thickish beam of light is necessary to make the polarization of its motes sensible. A much thinner beam suffices for common water; while with Brücke's precipitated mastic, a beam too thin to produce any sensible effect with most other liquids, suffices to bring out vividly the selenite colors.

CONTROLLING THE ARMATURES OF ELECTRO-MAGNETIC INDUCTION MACHINES.

BY MR. HENRY WILDE.

THIS was a paper on a Property of the Electric Current to Control and Render Synchronous the Rotations of the Armatures of a Number of Electro-magnetic Induction Machines, read before the Manchester Literary and Philosophical Society.

The discovery of the property which the author describes arose out of the efforts which have been made, during the last two years, to reduce the internal heat generated in large electro-magnetic machines by the rapid magnetization and demagnetization of the armatures. By constructing the machines of smaller dimensions, this heating was considerably diminished; but an inconvenient residuum of heat still remained when the machines were worked continuously for a long time, such as to render it desirable to adopt some means for abstracting the heat more rapidly.

By means of a current of water, circulating in the hollow brass segments which form part of the magnet-cylinder, Mr. Charles E. Ryder, the skillful manager at the works of Messrs. Elkington & Co., has happily succeeded in so far reducing this heating as to permit of the machines being worked, for days and nights together, without intermission, and without any sensible diminution of the power of the current.

The author has already shown, elsewhere, that the current from a small magneto-electric or electro-magnetic machine is sufficient to excite the electro-magnet of a very large machine: and it has been further found, by Mr. G. C. Lowe, that the current from one small machine is sufficient to excite, simultaneously, the electro-magnets of several small machines. In a number of $3\frac{1}{2}$ -inch machines which have been constructed, under the author's direction, for Messrs. Elkington & Co., for the electro-deposition of copper on a large scale, the current from two $3\frac{1}{2}$ -electro-magnetic machines are made to excite the electro-magnets of twenty similar sized machines to a degree sufficient to bring out the maximum dynamic effect of each machine.

The electro-magnets of two $3\frac{1}{2}$ -inch exciting machines are charged by the current from a small magneto-electric machine; but the author has found that nearly as good a result may be obtained from

the twenty machines, by dispensing with the small magneto-electric machine, and employing the residual magnetism of the two $3\frac{1}{2}$ -inch exciting machines, in a manner similar to that described almost simultaneously by Mr. Farmer, Messrs. Varley, Mr. Siemens and Sir Charles Wheatstone.

While the subdivisions of the materials of one large machine into a number of small ones was attended by several important advantages, yet it was found necessary to adopt some means to secure the synchronous relation of the armatures, when the combined direct current from several machines was required.

As the high speed at which the armatures were driven precluded the employment of toothed gearing, the only method which seemed at all feasible for producing the requisite synchronism was to place several machines in a straight line, and connect them together by means of a clutch fixed on the end of each armature spindle. It was while experimenting with a pair of machines so geared together that the author first observed the phenomenon which forms the subject of his communication.

The armatures of these machines were 4 inches in diameter, and each of them was coiled with a copper wire conductor, 280 feet long and $\frac{1}{8}$ inch in diameter. The currents were taken from the armatures by means of copper brushes rubbing against metal rings connected respectively with the ends of the armature coils, and were therefore in alternate directions for producing the electric light.

The clutch by which the armatures were connected consisted of two iron disks, about 4 inches in diameter, having in the face of one, two iron pins which could be guided into two corresponding holes in the face of the other. These disks could be engaged, or disengaged, either when the machines were at rest or in motion. The relative positions of the pins and holes in the disks were such that the armatures might be engaged in reversed positions of half a revolution, when required.

Each of the machines, when making about 2,000 revolutions per minute, was, of itself, capable of producing a very efficient electric light; and when the two armatures were clutched together in such a position that the united positive currents from both machines should proceed from one polar terminal, simultaneously with the united negative currents from the other polar terminal, the sum of the currents from the two machines was obtained. On the other hand, when the armatures were clutched together in the reversed

position, without any change being made in the armature connections, no current was produced outside the two machines.

These experiments, besides exhibiting the necessity of synchronous rotation, further showed that the armatures must also occupy the same relative position in the magnet cylinders, in order that the combined currents from the two machines might be obtained. It now occurred to the author to see to what extent the want of synchronism in the armatures would affect the magnitude of the current.

The armatures were therefore unclutched, and allowed to revolve independently of each other, in the same manner as when the attempt was made to take the combined direct current from the commutators. After the alternating current had been transmitted through the electric lamp for some time, it was found that there was no perceptible diminution in the amount of light produced from the carbon points, and that the current would melt, very nearly, the same quantity of iron wire as when the armatures were clutched together. On examining into the circumstances attending this unexpected phenomenon, it was first observed that whenever the machines were stopped, the pins and holes in the respective disks were exactly opposite each other; and that, while the armature were revolving, the two disks could at all times be engaged and disengaged with the greatest facility. Moreover, even when the disks were set (before starting the machine) a quarter, or half a revolution, out of the position in which the maximum amount of current was obtained, it was found that after the armatures had been revolving for a few moments, the disks resumed their normal positions with respect to each other (as indicated by the action of the clutch); thereby exhibiting, not only the synchronous rotation of the armatures, but also, that the machines contained a principle of self-adjustment to the position in which the maximum effect of the combined current was obtained. It was therefore evident that this property of the current, to maintain the synchronism of the armatures, rendered it unnecessary to employ mechanical gearing of any kind for that purpose.

The author then proceeds to enter into a detailed explanation of the causes which produce the synchronism of the armatures, a summary of which is as follows:—When the armatures happen to be in that position during their revolution in which they are producing the maximum and minimum amount of current respectively (as

must often be the case when there is no synchronism), that current which is at the maximum rushes through the coil which is producing the minimum amount of current,—the effect of this passage of the current from one coil to the other being to accelerate or retard the rotation of the armature (according to the direction of the current) until synchronism is established. On the other hand, the absence of synchronism observed when the direct current was taken from the machines, by means of commutators, is caused by the direction of the currents being coincident with that which they would receive by induction from the electro-magnets, and, consequently, opposite to that which tends to impart an accelerating or retarding impulse to the armatures.

The synchronous rotations of the armatures having been secured in the case of the combined alternating currents, it yet remained to obtain the combined direct currents from the two machines. A pair of rings and a commutator were therefore fitted upon one of the armature spindles, which was made sufficiently long for the purpose; and metallic connection was established between the rings of each machine and the commutator on the prolongation of the armature axis. As the commutator necessarily revolved synchronously with the two armatures, it was found that the combined alternating currents were rectified, just as if they had proceeded from only one machine; and were, consequently, available for electro-deposition, or for any other purpose for which a direct current might be required.

Although this property of synchronous rotation has, as yet, been observed only in the case of several pairs and a triple combination of machines, yet the author sees no reason for supposing that it may not be extended to any number of machines that may be conveniently worked together from the same prime mover. It is necessary, however, to observe that, as the controlling power of the current is only calculated to correct such minute deviations from synchronism as it is beyond the power of mechanical skill to prevent, the driving and driven pulleys should be, respectively, as nearly as possible of the same diameters, as the correction of any considerable difference in the number of the revolutions of the armatures, caused by differences in the diameters of the pulleys, must necessarily be attended by a corresponding diminution of the useful effect of the current outside the machines.

The author concludes his communication by directing attention

to an important property of the magneto-electric circuit, which renders the commonly accepted theory by which the generation and propagation of the electric influence in voltaic circuits is explained, inapplicable to those circuits which are entirely metallic. Reference to this property is all the more called for at the present time, as the author finds that a want of acquaintance with it has given rise to no small amount of misconception on the part of several eminent mathematicians and electricians, who have examined his experiments on the electric condition of the earth, and the method by which he has thought proper to estimate the magnitude of powerful induction currents.*

The intensity of a voltaic current, as represented by the mathematical theory of Ohm, is equal to the electro-motive force divided by the internal resistance of the battery; and from this theory it is inferred that an electro-motor, in order to overcome a great external resistance, must itself possess a correspondingly great internal resistance. A further consequence deduced from this theory, is, that the maximum useful effect of a given electro-motor is obtained when the external and internal resistances are equal.

Now, this mode of estimating the magnitude of an electric current does not apply to the circuits on the armatures of the machines invented by the author. Take, for example, the results obtained from the quantity armature of a 10-inch machine. The dimensions of the coil of this armature may be represented by a bar of pure copper 67 feet long, and having a sectional area of 1.6 square inches, so that the resistance which this circuit presents to the passage of a current, when compared with that of the liquids in a voltaic battery, is practically null. When the coil is in full action it will melt 15 inches of thin iron wire .035 inch in diameter, or the same length of $\frac{1}{4}$ inch iron rod with equal certainty; and will electrolyze acidulated water in at least 16 voltameters in series: so that the resistance outside the circuit, whether estimated by the 15 inches of thin wire melted, or by the number of electrolyzing cells in series, is more than one hundred times greater than that of the coil in which the current is generated.

Moreover, the author has found that whenever a voltaic battery and a magneto-electric machine will melt an equal length of wire, the power which these electro-motors have to overcome external

* *Philosophical Magazine*, August, 1868.

resistance, as measured by the number of voltmeters in series, is also equal. And generally the power of an electro-motor (whether voltaic or magneto-electric) to overcome external resistance, is directly proportionate to the length of wire which it will melt.

From a consideration of these results it will be seen that one of the fundamental elements which enters into the theory of Ohm is found wanting when that theory is applied to the estimation of the magnitude of currents generated in circuits entirely magnetic. M.M. Jamin and Roger, in a recent number of the *Comptes Rendus*, of the Academy of Sciences, have also pointed out the discrepancy here referred to in the application of Ohm's theory to magneto-electric circuits. The author is, however, by no means prepared to admit the correctness of the views advanced by these physicists in their endeavors to reconcile the facts observed, with established theory, besides which other anomalies present themselves when the customary formulæ are applied to magneto-electric circuits, a consideration of which must, as the author affirms, lead ultimately to the enunciation of laws much more general in their application than those with which we are at present familiar.

THE CAPTIVE BALLOON.

SIX months since we penned some remarks upon the interesting features which presented themselves to the scientific mind when up in a balloon. We then observed that in a very short space of time any one who had not been up in a balloon would be regarded as one behind his time, and would be placed in the same category as those who had never ridden in a Hansom cab, nor traveled on a railway. The time to which we then looked forward has arrived, and it is now open to any one who likes to take boat, 'bus, or rail to Chelsea, to make an ascent in one of the finest and best appointed balloons that ever floated in the air. This splendid aerostat is the property of M. Giffard, the inventor of the well known injector, and by whom it was constructed. It is now on view in the Ashburnham Park, Chelsea, where it is daily making captive ascents—weather permitting. In one of these ascents we had the pleasure of joining yesterday week, on the invitation of the proprietor, and which ascent we briefly recorded in our last number. On that occasion, Mr. Glaisher made the ascent with the view of taking

some meteorological observations near the earth, which the gradual ascent of a captive balloon would permit of, and which he had not been able to take in a free balloon, owing to the rapidity with which it always left the earth. On that occasion, too, there were present Lord Richard Grosvenor and Lord Dufferin, members of the council of the Aeronautical Society of Great Britain, Mr. Brearey (the secretary), Mr. T. Cargill, C. E., and several other scientific gentlemen. But the elements were unpropitious; a stiff breeze suddenly sprang up, which obliged the party to return to earth after an altitude of about 2,000 feet had been reached. The circumstance, however, served to show how perfect all the arrangements were, and how thoroughly under control the immense machine was. As we made the ascent shortly before going to press, we had not time to place the details of the apparatus before our readers; we, however, propose to do so now.

Those who visited Paris during the last Great Exhibition will, doubtless, remember M. Giffard's captive balloon, and the machinery by which the ascents and descents were regulated. This machinery has now been brought to London, together with a balloon 23 feet larger in diameter than the Paris balloon, and a rope of much greater length. On entering the Ashburnham Park, the visitor finds himself in a circus 246 feet in diameter, encircled by a screen of timber framing 80 feet in height, and covered with canvas. In the centre of this arena is a well about 15 feet deep, over which the balloon, when not on a journey, is held in place by numerous guy ropes. This balloon is 93 feet in diameter, and when inflated contains 421,161 cubic feet of gas, pure hydrogen being the gas used. The material of which the balloon is constructed is composed of one layer of linen interior, united to another layer of the same material, by means of a solution of india-rubber. Outside this is a layer of Cretonne linen, the attachment being formed by a vulcanized india-rubber composition. The exterior is finished with two coats of gum shellac varnish, over which again are laid fine coats of boiled linseed oil. From the balloon is suspended a circular car, having the centre open for the passage of the rope, which is attached directly to the body of the balloon. The car will accommodate about twenty-five persons; this was, in fact, the number that made the ascent to which we have referred. The rope is made fast to a pressure gauge, having a horizontal dial, upon which a pointer indicates the strain put upon the rope at any

moment. The balloon weighs 6,000 pounds; the core netting, with which it is covered, and the necessary guy ropes, &c., which are very numerous, are stated to weigh 4,000 pounds.

The main rope by which the balloon is held captive, weighs 4,350 pounds, is 2,150 feet in length, and is $2\frac{3}{4}$ inches in diameter at the end next the balloon, gradually tapering to 2 inches diameter at the end next the winding drum. The object of thus tapering the rope, is that its weakest part may be nearest the ground, at which point it would first give way, if it broke at all—which is hardly probable. By this means, if such an event did take place, there would be no danger to those below, from a heavy mass of rope falling upon them. It would also act somewhat as a brake upon the balloon, which would otherwise shoot upwards at a terrific rate, when suddenly relieved of its load. The rope passes from the balloon over a pulley wheel 5 feet 6 inches in diameter, which is so arranged that it allows the rope to pass freely over it, no matter what angle it may take. It is, in fact, swivelled horizontally and vertically, and has a heavy counterbalance weight attached to it. This pulley wheel is held down by a strong frame work, which is built into the earth, and is weighted with 50 tons of brick, iron and timber work. The rope passes horizontally from the pulley along a gradually widening tunnel to the winding drum which is placed at the far side of the circus. This drum is 23 feet in length, and 7 feet in diameter. It is cast in lengths, and is grooved to receive the rope. The drum is surrounded by a platform, at each end of which is a double cylinder steam engine of horizontal construction. These engines drive the drum by means of toothed gearing; they receive steam from two vertical boilers placed in the rear of the circus. The boilers are of French construction, by M. Duresnes, as are also the engines, which are by M. H. Flaud. The winding drum was made in London by M. Babeaud, the engineer in charge of the balloon machinery.

On a piece of spare ground in the rear of the circus is the apparatus for producing the gas. This consists of a series of wooden vats in which scrap iron is placed in a solution of sulphuric acid. The gas is drawn off to a receiver, and is made to pass through a washer and a purifier, after which it is stored in a gas holder ready for use. The balloon is always kept inflated, but there is always a loss going on from condensation, the deficiency being made good every evening. The cost of the balloon and apparatus has been

something considerable, as will be seen from the following items: Cost of balloon £2,000; netting, guy, and other necessary ropes, £2,000; main holding-rope, £220; engines, boilers, and machinery to work the balloon, £4,000; gas works, £1,200. These items—which are not all that could be enumerated—represent the respectable sum of £9,420, and when we add that the gas for one inflation costs £600, it will be seen that M. Giffard has made an investment of no light nature, but which we trust will prove as satisfactory to himself as his balloon will prove attractive to the public. A careful examination of the whole apparatus has satisfied us that everything is as safe as human ingenuity and foresight can make it. Two experienced aeronauts, MM. Godard and Aymo, accompany each ascent, whilst the manager is M. Yon, who manufactured the whole of the ropes and netting, and also constructed the balloon for M. Giffard. We can but wish success to this novel enterprise, which we are sure will be well patronized by the public, whenever the weather will permit of ascents being made. There is now no excuse for the public not enjoying the privilege of a balloon ascent, which luxury has hitherto only been allowed to a select few.

ON THE NEW CHEMICAL NOMENCLATURE.

BY DR. ADOLPH OTT.

"We must acknowledge that the present system of nomenclature must be abandoned, in order to give the true science of chemistry a rapid and onward impulse."
—James C. Booth, 1862.

The deficiency of the present system of chemical nomenclature, though immensely felt for many years, has chiefly been brought to light by the late astonishing strides of organic chemistry, or the chemistry of "carbon compounds," as termed by Kolbe. Here, the application of the principles predominating in mineral chemistry, resulted in the formation of names of such considerable length, that though indicating the composition of the respective bodies, they can scarcely be retained in the memory, are apt to mislead the novice in a thousand ways, and seriously to prejudice him at first against one of the most useful and interesting sciences. What shall we say of names with seventeen or more syllables, such as every text-book on organic chemistry now abounds with? And when it is known, as a distinguished writer asserts, that "the cata-

logue of the infinite number of substances which organic chemistry embraces, will shortly exceed that elaborated by astronomers for the stars themselves," it will be the better understood how great a drawback the retaining of the present scheme of nomenclature must be for the science referred to. Though in a less distinct manner, this deficiency has also been long felt in the domain of inorganic chemistry. We also meet here with scarcely pronounceable denominations, as "hypersulphomolybdate of potassa," "sesquibasicoammoniao-sulpharseniate of soda," "triphosphofluor-calcium," and many others; still their number is less, and they are therefore less conspicuous. We might for this reason also substitute empiric names for them. This system, however, evidently could not be well carried out in the domain of organic chemistry. The present scheme of chemical nomenclature is, moreover, not equal to the high demands of science, for reasons which shall be stated hereafter. Indeed, it cannot be considered as the expression of a system, since it must be learned as a language, which, in many cases is even so imperfect, that formulæ alone can give us a correct idea of the composition of bodies. Such is the present condition of chemical nomenclature.

Laurent in his "Chemical Methods," admits that "the problem of chemical nomenclature is so beset with difficulties, that from a thorough examination of them, we should be inclined to renounce the task of solution." Fortunately for the progress of science, these difficulties have been surmounted by an American savant, who in view of the words of *Regnault* that "chemical nomenclature can no longer be altered materially without great inconvenience," has invented an entirely new scheme, which in spite of its originality (and this is its great merit), is nevertheless built up in a true conservative spirit, and upon the foundation laid by the great men, who devoted their lives to the advancement of chemistry. It is self evident that a system like this must at once command our highest interest and participation.

It was first proposed at the meeting of the American Association for the Advancement of Science, held in the City of Buffalo, August, 1866, by the worthy Professor of Technology in the American Institute of the City of New York, *S. D. Tillman, L.L.D.*, and is found published in extenso in the proceedings of the above mentioned association, issued by Joseph Lovering, in Cambridge, in 1868.

In order to be able more fully to appreciate its high claims, we propose to devote some space to the rise and progress of chemical nomenclature.

The history of the spoken language of chemistry shows more clearly than that of any other science its various conditions in the succeeding stages of progress. The early cultivators of science hid their doctrines under the veil of an obscure, figurative, and enigmatic language, adopting at the same time, particular characters for signifying the various bodies known to them. In the belief that the celestial bodies exercised a direct influence on terrestrial products, they consecrated the metallic and other substances to the seven so-called planets. To Saturn were consecrated the lead, the litharge and agate; to Jupiter, the tin, corals, all white stones, the sandarac and the sulphur; to Mars, the iron, the loadstone, and the pyrites; to the Sun, the gold, the carbon, the diamond, the sapphire and hyacinth; to Mercurius, the quicksilver, etc.; to the Moon, the silver, etc., etc. Traces of this nomenclature yet remain in terms. as *Arbor Dianæ*, *tincture of Mars*, *Martial pyrites*, *Lunar caustic*, mercury, (which latter term has become universally employed) and others. The term *sal* is used since the oldest times, for everything tasting like salt, or even for substances, as the carbonate of potassa, which share only some properties with the same, viz., solubility in water, deliquescence and color. At a latter period, words referring to the origin of the respective substance are added thereto. Thus we have the expressions, *sal marinum*, *sal ammoniacum*, *sal petraë*, or *nitri*; *sal vegetabile* for potash, is also used at quite an early date. We find figurative expressions also quite frequently introduced into nomenclature. Alcohol* was called *aqua ardens*, *sal ammoniæ*, *amina sensibilis*, *cancer*, *lapis aquilinis*, *aqua duorum*, *fratrum*, *ex sorrore*, etc.

Yeber or Geber (ninth century), who first made us acquainted with the preparation of nitric acid and aqua regia, calls the former *aqua dissolutiva*, and so he designates the liquid obtained in subjecting alum to heat in a retort and collecting the rising vapors.

From the thirteenth to the eighteenth century, the various compounds are briefly denominated according to physical properties, or slight resemblances in some external characters to domestic articles.

* This word is derived from a Chaldaic verb, which signifies *to burn*, or *to terrify*.

We refer to names like *oleum vitrioli*, *rheum tartari*, *oleum martis*,* names which to some extent justify Dumas' in saying: "*Les chimistes semblaient avoir emprunté le langage des cuisinieres.*"

Spiritus fumans, *flores zinci*, *flores sulphuris*, are other names, expressing various significations. The term *salt* obtained still a wider signification than it possessed in ancient times. *Palissy*, the cotemporary of *Agricola* and *Paracelsus*, and himself the representative of a speedily growing science, in his treatise on "*Des sels divers*," embraces under the term *salt*, saltpetre, vitriols, alum, borax, sugar, sublimat, cream of tartar, and sal ammoniæ. Metallic bodies of an orange color were called *crocus*; *æthiops* if of a black one.

With the discovery of a greater number of compounds, especially of salts, which were lacking remarkable properties, recourse was had to the names of the discoverers. Thus the names *sal mirabile glauberi*, *sal polychrestum gluseri* took their origin. During the period of alchemy, nearly every chemist created his own nomenclature, only for the common substances, the expressions coincide greatly with each other. Towards the close of the seventeenth century, chemists agreed finally to establish similar names on the similarity of properties. The sulphates were distinguished as *vitriols*, the nitrates as *nitres*. The condition of chemical nomenclature as late as in the commencement of the eighteenth century may, however, be inferred from the fact that the black oxide of manganese was called *magnesia nigra*, in opposition to the *magnesia alba*, because it was supposed that these bodies were greatly similar to each other.

(To be continued.)

ON AN EASY METHOD OF MEASURING APPROXIMATELY THE INTENSITY OF TOTAL DAYLIGHT.

BY ROGER J. WRIGHT, Esq.

AN easy method by which the amount of light may be at any time measured and registered, appears to be still wanting. I would suggest the following plan, by which I believe the desired object may be attained.

We have a rod of solid metal, terminated by a heavy base, which keeps the rod in a perpendicular position, also a hollow tube, blackened inside, of such a diameter as exactly to fit and slide over the

* The Persian alchemist, *Rhasès* (860-940), according to *Hæfer* (vide his "*Histoire de la chimie*," I. 323), makes first mention of an oil obtained by submitting the *atramentis* (sulphate of iron) to distillation. *Hæfer* is even of the belief that this oil, our oil of vitriol, was known before *Rhasès*, in an epoch when the distillation was one of the principal manipulations of the chemist, as it is also to-day.

rod. The upper extremity of the rod is painted of a snowy white, with a jet black spot in the centre. On the rod is marked the scale, beginning with zero at the base. The tube is pushed over the rod till the lower extremity coincides with the zero line.

The method of using this instrument is as follows:—Draw the tube gently up the rod, at the same time looking steadily at the black spot before mentioned. It will be found, as the tube ascends, that the black spot will gradually disappear, and ultimately vanish in the gloom; it will also be found that on *different days, and different hours of the same day, the point at which the black spot vanishes will vary with the intensity* of the light. This point is read off on the graduated scale, and thus we are enabled to measure the intensity of the light at any required time. In taking an observation, it would be well to state whether that portion of sky round the zenith from which the cone of rays proceeds be clear or cloudy.

It will be seen that the result obtained by this method is not *scientifically* correct, as it will be affected by the eyesight of the person who makes the observation, but only in a slight degree. The method of measuring light, as just described, has been known to me for upwards of three years. The hope that I should some day be enabled to make the instrument *scientifically* correct, has hitherto prevented me from making it public. As I understand that it is highly desirable to have some means of estimating the changes in the light which will occur during the total eclipse of the sun in August next, I no longer feel justified in keeping in the back-ground an instrument which may *possibly* be of some slight assistance.

ON THE MEASUREMENT OF THE LUMINOUS INTENSITY OF LIGHT.

BY WILLIAM CROOKES, F.R.S., &c.

THE measurement of the luminous intensity of a ray of light is a problem, the solution of which has been repeatedly attempted, but with less satisfactory results than the endeavors to measure the other radiant forces. The problem is susceptible of two divisions, the absolute and the relative measurement of light.

A relative photometer is one in which the observer has only to ascertain the relative illuminating powers of two sources of light, one of which is kept as uniform as possible, the other being the light whose intensity is to be determined. It is therefore evident that one great thing to be aimed at is an absolutely uniform source of light. In the ordinary process of photometry the standard used is a candle, defined by Act of Parliament, as a "sperm of six to the pound, burning at the rate of 120 grains per hour." This, how-

ever, is found to be very variable, and many observers have altogether condemned the employment of test-candles as light-measures.

The author has taken some pains to devise a source of light which should be at the same time fairly uniform in its results, would not vary by keeping, and would be capable of accurate imitation at any time and in any part of the world by mere description. The absence of these conditions seems to be one of the greatest objections to the sperm-candle. It would be impossible for an observer on the continent, ten or twenty years hence, from a written description of the sperm-candle now in use, to make a standard which would bring his photometric results into relation with those obtained here. Without presuming to say that he has satisfactorily solved all difficulties, the writer believes that he has advanced some distance in the right direction, and pointed out the road for further improvement.

A glass lamp is taken of two ounces capacity, the aperture in the neck being 0.25 inch in diameter; another aperture at the side allows the liquid fuel to be introduced; this consists of alcohol of sp. gr. 0.805, and pure benzol boiling at 81° C., which are mixed together in the proportion of five volumes of the former and one of the latter. The wick-holder consists of a platinum tube, and the wick is made of fifty-two pieces of platinum wire, each 0.01 inch in diameter. The flame of this lamp forms a perfectly shaped cone, the extremity being sharp, and having no tendency to smoke; without flicker or movements of any kind, it burns when protected from currents of air at a uniform rate of 136 grains per hour.

There is no doubt that this flame is very much more uniform than that of the sperm-candle sold for photometric purposes. Tested against a candle, considerable variations in relative illuminating power have been observed; but on placing two of these lamps in opposition, no such variations have been detected.

The instrument devised for measuring the relative intensities of the standard and other lights is next described; it has this in common with that of Arago described in 1833, as well as with those described in 1853 by Bernard, and in 1854 by Babinet, that the phenomena of polarized light are used for effecting the desired end.* But it is believed that the present arrangement is quite new, and it

* Since writing the above, I have ascertained that M. Jamin had previously devised a photometer in which the principle adopted in the one here described is employed, although it is carried out in a different, and as I believe, a less perfect manner.—W. C., Dec. 16, 1868.

certainly appears to answer the purpose in a way which leaves little to be desired. The instrument cannot be described without the aid of drawings which accompany the original paper, but its mode of action may be understood by the following description.

The standard lamp being placed on one of the supporting pillars which slide along a graduated stem, it is moved along the bar to a convenient distance, depending on the intensity of the light to be measured. The light to be compared is then fixed in a similar way on the other side of the instrument. On looking through the eyepiece two brightly luminous disks will be seen, of different colors. one of the lights must now be slid along the scale until the two disks of light, as seen in the eyepiece, are equal in tint. Equality of illumination is easily obtained; for, as the eye is observing two adjacent disks of light which pass rapidly from *red-green* to *green-red*, through a neutral point of no color, there is no difficulty in hitting this point with great precision. Squaring the distance between the flames and the centre will give inversely their relative intensities.

The delicacy of this instrument is very great. With two lamps, each about 24 inches from the centre, it is easy to distinguish a movement of one of them to the extent of one-tenth of an inch to or fro, and by using the polarimeter an accuracy exceeding this can be attained.

The employment of a photometer of this kind enables us to compare lights of different colors with one another. So long as the observer, by the eyepiece alone, has to compare the relative intensities of two surfaces respectively illuminated by the lights under trial, it is evident that, unless they are of the same tint, it is impossible to obtain that absolute equality of illumination in the instrument which is requisite for a comparison. By the unaided eye one cannot tell which is the brighter half of a paper disk illuminated one side with a reddish, and on the other with a yellowish light; but by using the photometer here described, the problem becomes practicable. When the contrasts of color are very strong (when, for instance, one is a bright green and the other scarlet), there is difficulty in estimating the exact point of neutrality: but this only diminishes the accuracy of the comparison, and does not render it impossible, as it would be according to other systems.

EDUCATIONAL

SPECTRUM ANALYSIS.

BY PROF. HENRY MORTON, PH. D.

(Continued from page 62.)

THE first of the general laws of spectrum analysis, as deduced by its founders, Kirchhoff and Bunsen, was that, while solids and liquids, either in mass or separated in fine particles, when incandescent, emitted light of continuously various rates of motion, (*i. e.* of all the intermediate rates between their extreme ones); incandescent gases, on the contrary, emitted rays of only a limited number of definite rates.

Consequently, when the light from a solid or liquid is decomposed by the action of a prism, as explained in our former paper, it will yield a continuous spectrum, because every shade of color between those constituting the extremes is present, and will, therefore, fill its appropriate intermediate place; but the light from a gas or vapor, on the other hand, will yield an interrupted spectrum, consisting of bright lines with blank or dark spaces between them, because only certain rates of vibrations or colors are present, and the intermediate ones are wanting.

It was, at first, supposed that the number and position of lines in gaseous spectra were unaffected by the temperature of the gas, but were always the same, for the same substance, even when in different combinations with other elements.

Subsequent researches have served to modify these conclusions in certain respects as we shall proceed to show.

Drs. Frankland and Tyndall, in 1861, both about the same time observed by accident that in the electric arc Lithium developed a brilliant blue line in its spectrum which is not found when it is heated in a Bunsen burner, or even in the oxohydrogen flame.—*Phil. Mag.*, 1861, p. 473. Again, in 1865, Prof. Plucker, of Bonn, observed that by variously modifying the intensity of an electric

discharge through Geissler tubes containing rarefied gases and vapors, at least two and sometimes three entirely distinct spectra might be developed from the same element, and that under certain conditions of great intensity, the lines were so expanded as to produce a sensibly continuous spectrum even from a rarefied gas, (see *Phil. Trans.*, 1865, Vol. CLV., p. 20; also this *Journal*, Vol. LVII., p. 271.) Yet again, in 1867, Dr. Frankland, in a lecture on the "Source of Light in Luminous Flames," reprinted in this *Journal*, Vol. LVII, p. 330, showed that vapors and gases under certain conditions might yield continuous spectra.

Lastly, with regard to the effect of composition with other elements we have the researches of M. E. Diacon, published fully, with illustrations, in the *Ann. de Chem. et de Phys.*, Sept., 1865, and in abstract in *Chemical News*, 1865, p. 243.

It was here proved that under such special conditions as, for example, heating a chloride in a flame of hydrogen and chlorine out of contact with air, the spectra of some substances was entirely altered, and that of others much modified, though with some, no change was produced.

All these modifications of the general law imply special and marked conditions, however, which it is impossible not to recognise, and thus we may practically regard the general law that the spectrum lines of each substance are fixed characteristics, and that discontinuous spectra indicate a gaseous state, as generally reliable.

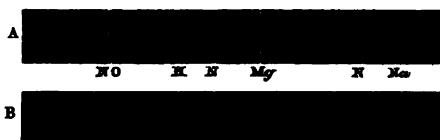
The most remarkable applications of this law which have been made, are to the investigation of the constitution of nebulae and comets and to the luminous prominences or flames seen around the sun during total eclipses.

With regard to the first, we will here only note that Messrs. Huggins and Miller, by a series of observations, of which a more complete account is given in this *Journal*, Vol. L., p. 284, showed that while some nebula gave a continuous spectrum, and were, therefore, presumably composed of star-clusters, others gave spectra of a few bright lines only, chiefly corresponding with hydrogen and nitrogen gases, and were, therefore, presumably not of stellar, but of truly nebulous composition.

Spectrum B, on Fig. 1, shows the normal nebular spectrum, A, giving the most prominent lines of nitrogen, oxygen, magnesium and (Na) sodium.

By this means a new light was thrown upon the nature and condition of these bodies, and the attention of astronomers was directed to their possible proper motion which had not before been studied with this view on account of their supposed enormous distance.

Fig. 1.



Similarly, by observation of such comets as have been visible since the development of this process, it has been shown that, while the light emitted by the tails is probably due to reflected sunlight, that coming from the nucleus is of gaseous origin. Thus, the comet II. of 1868 gives a spectrum such as is seen in Fig. 2, and

Fig. 2.



corresponding exactly with that of ignited carbon vapor. Unfortunately, the supply of comets during the last year or two has been small, and not of a brilliant character, the only other which admitted of spectroscopic study being Brorson's, which was of small size and gave the spectrum (shown in Fig. 3) which has not yet been identified.

Fig. 3.



The next general principle or law of spectrum analysis may be thus stated. Each substance will absorb exactly those kinds of light which it emits when self-luminous. Thus, as we have seen, sodium vapor emits essentially pure yellow light of a character which we may more exactly express by saying that its rate of vibration is 527,000,000,000,000 times per second. If, now, a ray of white light is caused to go through a mass of sodium vapor, all the colors will pass freely except the yellow, whose vibrations are at the rate mentioned above. These will be absorbed by the vapor, and, while adding to its general luminosity, will be abstracted from the traversing beam, so that when it is subsequently separated by a prism into its constituent colors, in the manner described in our first article, the yellow will be wanting, and thus, in the spectrum produced, a black space or line will appear in the yellow part.

This is not a meaningless, unreasonable or isolated rule, but one

which is a natural deduction from general principles, and in accordance with the universal laws of mechanics.

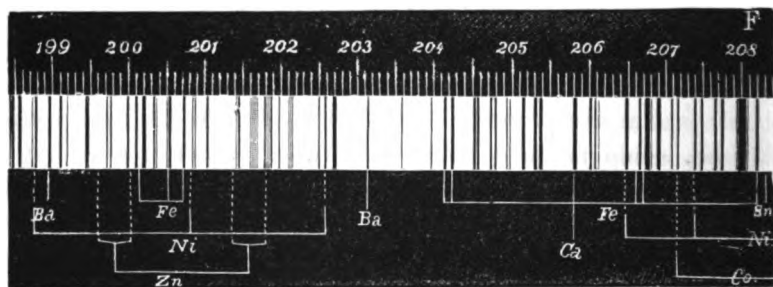
This we will endeavor to make plain. Keeping in mind that light is simply a rapid vibratory motion, it is clear that if a substance is capable of emitting exclusively one color of light,—that is, vibrations of one particular rate alone,—this must be because its particles are so constituted that they can only vibrate at this rate. So is it with a piano-string: it always gives one note, because its length, weight and tension are so adjusted that it can vibrate at one rate and no other. If, now, a series of vibrations following each other at exactly this rate strike upon this string, they will communicate their motion to it, because the first will give it a little impulse, too slight to be perceptible, but yet something, and the second will arrive just in time to add to this at the next swing, and the third again in its turn, until the accumulated effect becomes sensible. Thus with a swing. Suppose that a swing was of such a length that it made its full vibration forward and back again in three seconds (this would require it to be about twenty-nine feet and three inches long), and that we gave it a series of light pushes exactly three seconds apart. The first push would move it a little, and it would sway forward and then come back beyond where it started, and would then (exactly three seconds after the first push) be about to move forward again without external aid; but exactly at this instant would come push second, and adding to the acquired impulse, would make it go forward twice as much as at first, so that it would come back again twice as far, and so be ready at the end of the second three seconds to start forward with a double impulse; but at this auspicious moment would come the third push to add to this motion, and so on. Thus, a series of impulses, each alone too small to produce a sensible effect, would thus, properly timed, aid each other and accumulate motion, as it were, in the vibrating body.

I assume that my readers are aware of the fact, first observed by Galileo in watching a hanging lamp in church, that within moderate limits, a pendulum of a fixed length vibrates in the same time whether it moves through a great arc or a small one. When it goes far it goes fast; when a short distance, slow,—just so as to keep the time of the swing or beat constant.

But let us suppose that the pushes to the swing were given every two seconds; then the second push would meet the swing just as

it was one-third way back on its return motion, and nearly the entire force of this second push would be then expended in checking the return motion, and the swing would almost come to rest. The third push would then start it again, but only to be stopped by the fourth, and so on. It is clear that the discord, the want of equal timing in the vibrating body and the source of motion, will prevent a transfer of this motion from one to the other. This may be demonstrated in various ways. Let a tuning-fork be set upright in a stand on a table. Then sound another which is in exact accord and bring it near the first for a moment. On removing the second fork, we will find that the first is singing. The sonorous waves in the air, developed by the second fork, struck the other just at the right time after one another. But if the same experiment is tried with forks differing ever so little in pitch, no motion will be communicated. Exactly so is it with the vibrations of light. If a ray, containing all rates, falls upon a body capable of vibrating but at one rate, the vibrations of that rate are transferred to the body as above described, while the others travel on unaffected.

Fig. 4.



It will thus be seen that the property of "elective absorption" is not only capable of explanation, but is even a natural deduction and consequence of the undulatory theory of light.

Bunsen and Kirchhoff were the first, however, to discover this fact, and by a careful series of experiments, not only to establish its universal truth, but also to apply it to the most wonderful investigations. Thus, by a comparison of the black lines found in the solar spectrum, with the bright ones developed by various elements, they showed that our luminary contained in his atmosphere, hydrogen, sodium, iron, magnesium, calcium, copper, cobalt, barium, nickel, and that, on the other hand, mercury, lithium, copper, silver,

zinc, tin, lead, antimony, aluminum, cadmium, etc., were absent. Thus accomplishing the incredible feat of analyzing a body which was more than ninety millions of miles away, and which it would take us about three years to reach, if we could travel towards it at the rate with which a cannon-ball leaves the mouth of a cannon.

Fig. 4 represents a small part (about one-twelfth) of the chart of the solar spectrum prepared by Kirchhoff. The central band shows the lines observed in the solar spectrum. The diversions above are those of an arbitrary scale employed by this observer. The letter F indicates a very strong band in the greenish-blue of the spectrum, before observed and so named by Fraunhofer, and corresponding with one of the bright lines produced by hydrogen. The light lines on a black ground below, indicate the positions of bright bands produced by various elements in which the coincidence of some and want of coincidence in others with the lines of the spectrum above, are evident on inspection. The chemical symbols of the elements are used to indicate them. Thus Fe stands for iron, Ni. for nickel, Co. for cobalt, Ca. for calcium, Zn. for zinc, and Ba. for barium.

(To be continued.)

SPECTROSCOPIC NOTES.

BY PROF. C. A. YOUNG, OF DARTMOUTH COLLEGE.

IN observing the spectrum of the chromosphere, I find two bright lines, not heretofore observed so far as I know. The first corresponds exactly to a small dark line, 1474 of Kirchhoff's scale near E, given both by him and Angstrom, as an iron line. It is difficult to see, and is not noticeable in the spectrum of the protuberances, but only in that part of the chromosphere close to the body of the sun. It is best seen by using power enough on the telescope to get an image of the sun about six inches in diameter, and placing the edge of the disc just *tangent* to the slit of the spectro-scope collimator. It was first recognized July 8.

The other line is at (or very near) 664 of Kirchhoff's scale, between B and C. I have seen it only twice, both times in the spectrum of a protuberance. The first time (June 25), though only seen a few moments, it was bright and distinct. As seen again to-day, it was much fainter, but I think unmistakable.

The instrument employed consists of a comet-sceker of 4 inches

aperture, and 30 inches focal length, provided with a spectroscope of 5 glass prisms of 45° ; the spectroscope having an aperture of $2\frac{1}{4}$ inches, and 17 inches focal length. The whole apparatus is mounted equatorially.

The forms of the protuberances as seen by merely opening the slit, and looking at them through the c line (which appears then like a chink through which one looks out upon sunset sky), are very beautiful and fantastic, closely analogous to the light cirrus clouds of a spring or winter day, and varying nearly as fast. An hour sometimes almost wholly changes one. There are commonly four or five of them on the edge of the sun's disc at once. Usually, the chromosphere is found all around the sun with an average depth of from 15 to 30 seconds. To-day (July 19), a place was observed where the chromosphere was hardly perceptible; it was not more than 5 seconds deep, and very faint at that. Its position was on the south-east edge of the disc, 128° from the north point, very near a spot of considerable size, which had only advanced a few minutes of arc upon the limb. May not this deficiency in the chromosphere indicate the precise position of a spot just coming round the limb?

Dartmouth College, July 19, 1869.

CAMPHORIC ACID AND SOME OF ITS COMBINATIONS.

BY ROBERT FAIRTHORNE, ESQ.

NOT having been able to find any full description either of camphoric acid or its salts, I thought that perhaps others might have met with a similar disappointment and that the following communication would not be out of place in this *Journal*.

By repeated distillation of camphor with nitric acid, that hydrocarbon is converted into camphoric acid by absorption of six equivalents of oxygen, two of which appear to unite with two atoms of hydrogen, differing therefore from camphor, not only by the addition of the oxygen, but by two equivalents of the hydrogen being abstracted. The composition of camphor being $C_{20} H_{16} O_2$, that of camphoric acid is $C_{20} H_{14} O_6 + 2 H O$.

The combinations of this acid with the alkaline or metallic oxides are peculiar, and possess considerable beauty of form. I shall strive, however, to describe the appearance of the acid first.

The crystals from the nitric acid solution generally arrange themselves in shining, white, transparent tufts, having a hemispheroidal shape, the flat surfaces of which float on the top of the nitric acid solution, whilst prismatic crystals radiate downwards from central points in the disks.

A still stranger form of crystallization is sometimes produced from its solution in the same acid, for which I have been at a loss to account.

It takes the form of minute opaque, white, leaf-like crystals, have a close resemblance to elaborately carved ivory, each crystal being about the eighth of an inch long and about the twenty-fourth of an inch wide across the centre, and of an ovate form.

From its alcoholic solution it solidifies in stellar transparent crystals.

As obtained from its ethereal solution it is found not only as just described, but in long prisms also, having terminations which have somewhat of a feathery appearance.

It dissolves freely in alcohol and ether but is insoluble in benzine and chloroform. It is soluble to a moderate extent in water above 150° F., and to a small extent in cold water. It combines readily with ammonia and the other alkalies. The ammonia salt crystallizes in silky star-like crystals, having a peculiar appearance.

The aqueous solution of this salt reacts in the following manner with the articles hereafter named. With solution of the sesquioxide of iron a light brown precipitate with a reddish hue is thrown down. It might almost be described as of a flesh color. The same result follows when mixed with the solution of the sesquisulphate. When added to the solutions of the proto-salts of iron no precipitation occurs.

Mixed with the solutions of the sulphate of copper, a bright green precipitate is thrown down. Even with a solution containing so small a quantity of the sulphate as one grain in the pint, a decidedly marked color is produced, after allowing the mixture to stand for a few minutes. This color is so peculiar that I would propose it as a test for copper.

With solutions of salts of lead a dense white precipitate is formed. With solutions of salts of mercury a similar precipitate is formed, and with the following solutions no precipitation is apparent, namely, with that of sulphate of zinc, of sulphate of morphia, of sulphate of

quinine, of sulphate of cinchonia, of sulphate of magnesia. Neither is any produced with lime water.

It appears curious that the transparency of solution of nitrate of silver is not disturbed by the addition of the camphoric acid or of the camphorate, as most acids of a vegetable origin produce dense precipitates with that salt.

Philadelphia, July 9, 1869.

New Oxygen Process.—Oxygen procured cheaply and easily, is, as we have often said, a very desirable thing. The numerous applications that could be made of it are so evident that we need not stop to mention them, but we lay before our readers yet another plan, and this time an ingenious one, for obtaining it. The mineral sources of oxygen being comparatively expensive. MM. Montmagnon and Delaire have betaken themselves to that cheap reservoir, our atmosphere, and have further availed themselves of the discriminative action of wood charcoal and water, or certain saline solutions. We give here, it must be understood, the figures of the authors named, without checking them by a reference to the figures of Dr. August Smith, who has made most careful experiments on the absorptive action of charcoal. According, then, to our authors, 100 litres of fresh wood charcoal will, when exposed to atmospheric air, occlude 925 litres of oxygen, but only 705 litres of nitrogen. Now, it would appear that when the charcoal so saturated with gas is thoroughly saturated with water, there will be expelled 650 litres of nitrogen, but only 350 litres of oxygen. Thus we have now left in the pores of the charcoal 575 litres of oxygen, and only 45 litres of nitrogen, that is, oxygen practically pure for industrial purposes. To extract the gases, the authors employ a pump, and they tell us that if again exposed to charcoal, the oxygen will be obtained almost pure. There can be no doubt of it. They give no account of the cost of oxygen; but it is clear that it will be represented chiefly by the cost of the machinery and cost of working it.—*Mec. Mag.*

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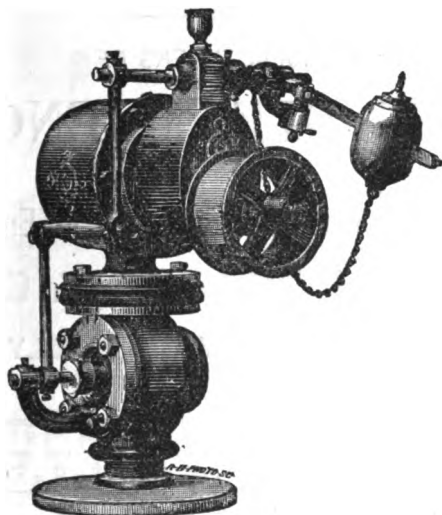
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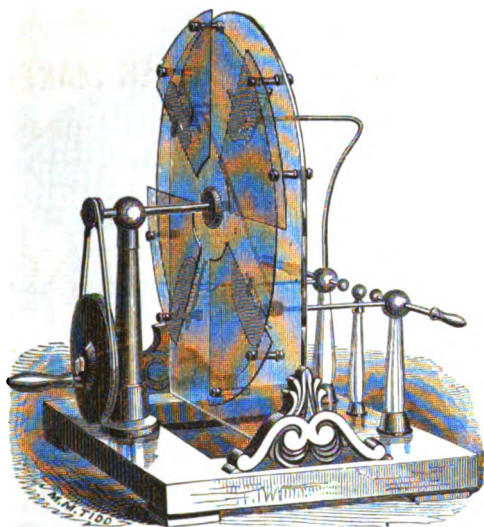
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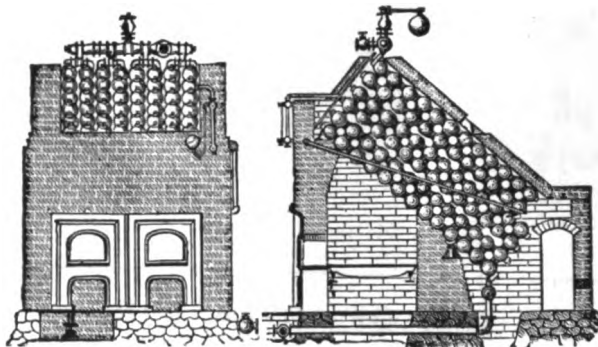
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The amount of raw sugar we refined during that time was larger than ever before. The steam pressure was always kept over fifty pounds, and we were therefore enabled to do more work in a shorter time with the same machinery and apparatus than with our old steam boilers, in which the pressure, at times, could not be kept up higher than twenty to thirty pounds.

The actual saving in fuel, during this time, was one thousand and seventy-one tons of coal.

Yours truly,

GUSTAVUS JASPER, Superintendent.

Worcester, Mass., February 1, 1869.

JOSEPH HARRISON, Jr.

Dear Sir:—After using one of your thirty-one horse power boilers sixteen months, it gives me great pleasure to say that it has proved, in every particular, entirely satisfactory. I have had many opportunities to recommend it, which I have done with pleasure. For economy in fuel, it excels all boilers in use. I can raise steam in shorter time than in any boiler I have ever seen; and would cheerfully recommend it as the cheapest, safest, and most economical boiler ever in use.

Very respectfully yours,

A. N. WHEELER.

OFFICE OF THE GRANITE STATE MILLS,
Newport, N. H., February 1, 1869.

JOSEPH HARRISON, Jr., Esq.

Dear Sir:—Yours of January 9th, asking our opinion of the Harrison Boiler, is at hand. We have had your boiler in use fifteen months, and it gives us perfect satisfaction in quickness of raising steam, and the cheapness of running it, as compared with the old-fashioned boilers. Our boiler does not yet leak a drop, and we do not believe it ever will; and last, though not least, our workmen about it do not feel obliged to get their lives insured.

Yours truly,

COFFIN & NOURSE.

Concord, N. H., February 8, 1869.

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Dear Sir:—Your favor of January 9th came duly to hand. The 63½ horse power boiler, which we had of you in October, has, from the time we commenced its use, until now, given perfect satisfaction, and we can see no reason why it should not continue to do so. It is the only boiler (and we have had a variety of kinds,) that suited us from the first. We save fuel, are troubled with no leakage, and feel safe in using it. We can only say that it meets more than our expectations.

Truly yours,

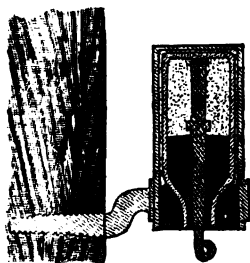
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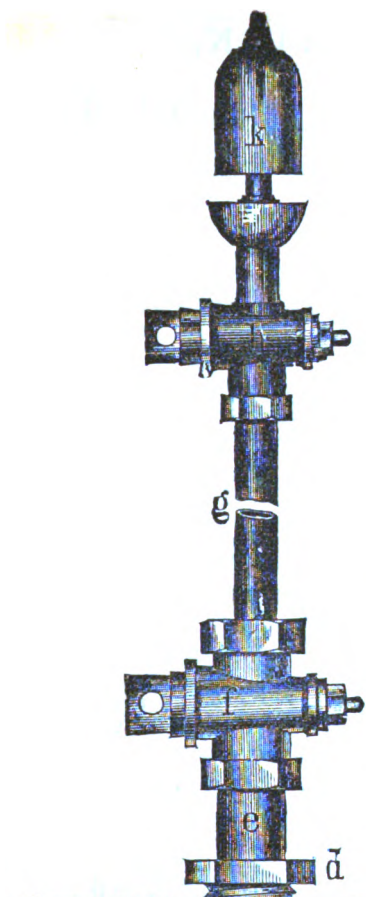
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mains, whilst hard, as a permanent barrier to the water, which is always cold at cock, *k*; but when, by reason of the water line, *b*, falling to an unsafe point, steam takes the place of the water in the tube, the resin melts, it is almost immediately blown out from the bowl aperture of the cock, and the whistle gives notice of the danger from *low water in the boiler.*

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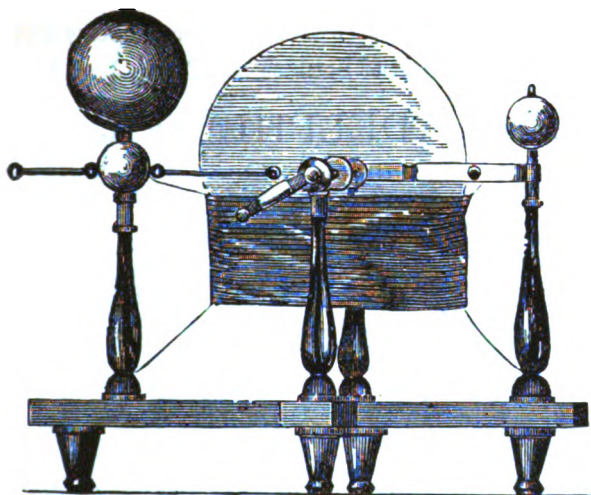
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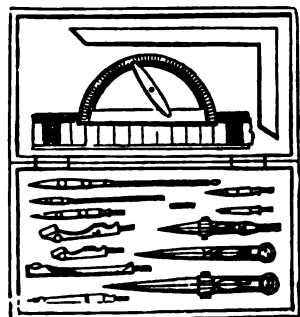
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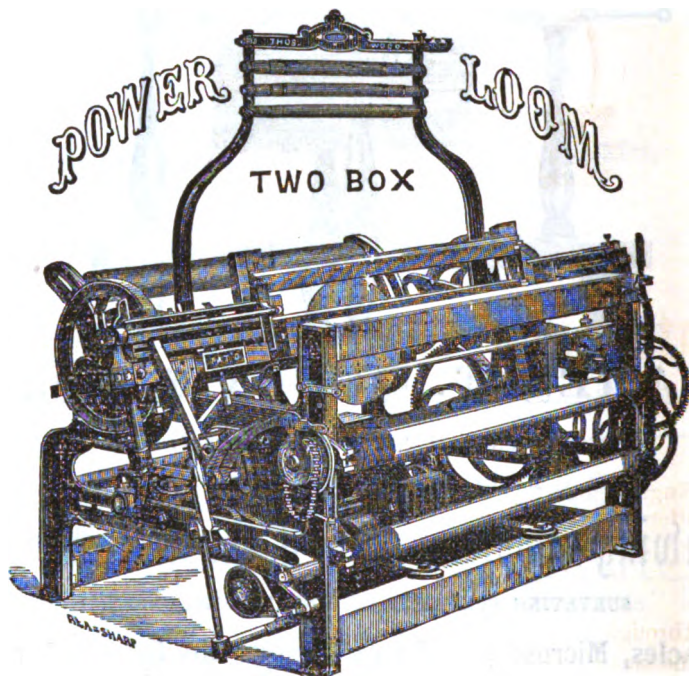
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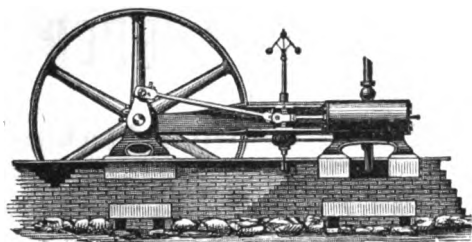
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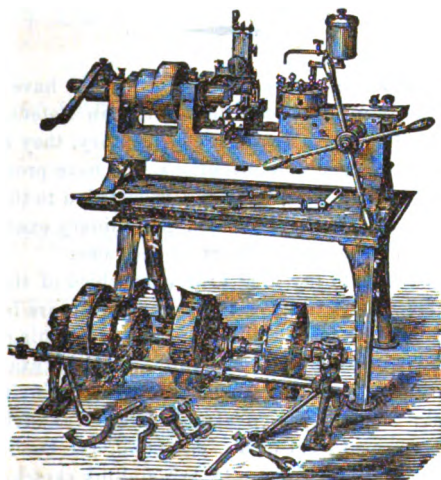
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FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LVIII.]

SEPTEMBER, 1869.

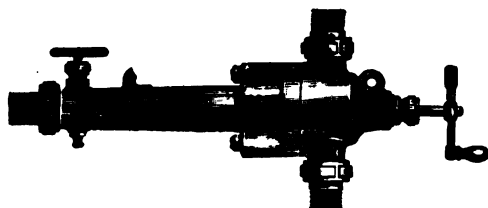
[No. 3

EDITORIAL.

ITEMS AND NOVELTIES.

The Giffard Injector.—We were lately much interested in witnessing a very unusual performance by a Giffard injector of the self-regulating form devised by Mr. Wm. Sellers, and shown in the accompanying cut.

During the late water famine, from which our city has been suffering, attention has of course been drawn on all sides to any independent source of supply which could be rendered available.



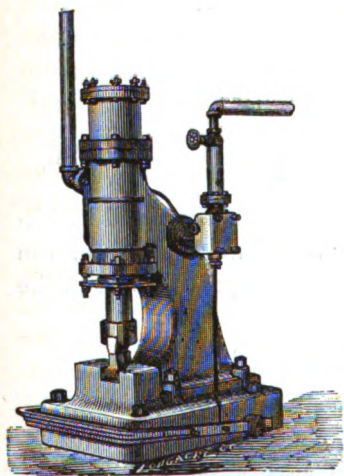
Thus the Messrs. Sellers finding that in the basement of the new

VOL. LVIII.—THIRD SERIES.—No. 3.—SEPTEMBER, 1869.

19

foundry, which they are erecting on the other side of Hamilton Street, was a strong and constant spring, determined to place an injector immediately above it, and supply their boilers from that source. The distance between the boilers and injector is a little over 250 feet, and it might be supposed that such a distance as this would introduce serious practical difficulties in the working of the instrument. Such, however, has not proved to be the case. Owing to its self regulating capacity, no adjustment is required at the injector, no matter what may be the variations in the steam pressure. Large connecting pipes being employed, the only loss involved in this wide separation seems to be that due to radiation of heat, which, were the arrangement a permanent one, it would of course be easy to prevent by a free use of non-conducting material on the connecting pipes. When the return flow to the boiler is obstructed, a pressure of 80 pounds is produced in the injector from one of 60 pounds in the boiler.

The Joy Hammer.—This hammer is peculiarly adapted for drawing down iron or steel, in which operation a rapid succession of uniform blows is required, with only a gradual alteration in the force of the successive strokes.



It therefore becomes possible to dispense with the complication of separate valves, and thus remove much of the risk of derangement and source of wear.

In this instrument the ram contains openings which are brought by its own motion into communication with passages for the inlet and escape of steam, and thus cause its motion to be automatically reversed. The only valve in the hammer is the throttle valve governed by a treddle, and by the adjustment of its opening both the rapidity and force of the blows is at the same time regulated.

As many as five hundred blows in a minute may be readily struck, and from the simplicity and solidity of all parts, there is the least possible chance of derangement.

A Big Belt.—The New York Belting and Packing Company

have lately had on exhibition at their store, New York, an india-rubber belt 4 ft. wide, 320 ft. long, and weighing no less than 3,600 pounds. It is intended for the main driving belt of the largest grain elevator in Chicago.

Hammering Iron until it is Red-hot.—In his lectures on "Heat," delivered recently at the London Institution, Mr. G. F. Rodwell alluded to a singular case of motion transformed into heat, namely, the rendering of iron red-hot by repeated strokes of the hammer. If Mr. Rodwell, who is so well versed in the history of science, will turn once more to the works of Robert Boyle, he will see that this "father of chemistry" had notions of the transformation of mechanical movement into heat very nearly akin to, if not quite identical with, those professed at the present day. Robert Boyle alluded to the rapid development of heat in an iron nail by repeated blows of the hammer *after it has ceased to travel* into the wood. It has been asked whether iron could be hammered cold until it became red-hot. Mr. Rodwell informs us that it can. Having requested a blacksmith to try the experiment, a piece of very tough iron was hammered with a moderately heavy hammer; it became hot, but would not scorch a piece of paper. It was then hammered by two men, one of whom used a sledge hammer, but with no better result. Presently, a man who was working in the shop said he had often lit his forge-fire by this means, before matches were plentiful. He took a nail, such as is used for horse-shoes, and, after hammering for less than two minutes with a light hammer, part of the nail was brought to a bright red heat. The blows were light but frequent, and the nail was partly turned at each blow.—*Scientific Review*.

The East River Bridge, U. S. A.—The plan of the East River bridge, as proposed by Mr. Roebling, has met with the approval of the Board of U. S. Engineers, appointed to examine it, and of the Government, and has been fully adopted by the Board of Consulting Engineers, consisting of Horatio Allen, William J. McAlpine, J. J. Serrell, Benjamin H. Lathrop, James P. Kirkwood, and J. Dutton Steele, who have made to the directors of the Bridge Company their final report, of which the following is the substance:—The plans, including foundations, towers, and superstructure have been laid before the Board by Mr. Roebling at various times between February 16 and April 26, and from him they have received the fullest information touching all the details. Having completed the

examination of the plans and the investigation of the combinations and proportions proposed, the Board deemed it an appropriate part of their duty to examine the structures of the same general character erected by Mr. Roebling across the Monongahela and Allegheny, at Pittsburgh, in 1846 and 1860; across the Niagara Falls in 1850, and across the Ohio, at Cincinnati, in 1860. They have thus had an opportunity of learning the successive steps in bridge building, which, beginning with a span of 822 in 1854, and one of 1,057 feet, in 1867, all standing this day—a practical demonstration of the soundness of the principles and proportions on which these structures have been erected, and rendering unnecessary, at least for spans of 1,000 feet, any other demonstration, and affording the best source of information as to the practicability of taking another step in a span of 1,600 feet. The bridge proposed by Mr. Roebling, a steel wire cable suspension bridge, 1,600 feet between the towers, 135 feet above the water, will be, in the opinion of the board, a durable structure of a strength sufficient to withstand six times the strain to which it can under any circumstances be subjected, that it will bear the action of the greatest storm of which we have any knowledge, and that the method of joining the parts cannot be surpassed for simplicity and security in the result.

Gas Blasting.—The "*Advertiser*" and "*Times*," Oswego, N. Y., says, "We saw a novel experiment involving the explosive power of gas. In the new tank excavation, now in a forward state, at the gas works in this city, an old well had been pumped out and then filled up, after leaving an aperture beneath. Into this space a limited quantity of gas was introduced from the gas pipe, sufficient to form an explosive compound with the air in the covered well. A match trigger touched off the mine, when a general upheaving of the surrounding earth took place, loosening up the soil and making easier digging."

A Rapid Change of Gauge.—In Missouri last month the Missouri Pacific Railway, a road nearly 200 miles long, changed its line from the broad to the narrow gauge. Nearly 1400 men were engaged in the work, and they labored with such celerity that the task was accomplished in twelve hours, and without interrupting the business of the road.

Explosion of Nitro-Glycerine at Cwymglo, at the foot of Snowdon. From various reports which have reached us, we gather that on Tuesday, a vessel, laden with nitro-glycerine, arrived at

Carnarvon Bar, the cargo being conveyed in boats to Carnarvon Pier. Next day, five cart loads were dispatched, two for Assheton Smith's Llanberis Quarries, and three for Lord Penrhyn's Bethesda Quarries. When the former two were near Cwymglo, the nitroglycerine exploded, blowing the horses and three men to atoms. The village, which is nearly a quarter of a mile off, was greatly injured, roof and windows blown off, and, at the spot where the carts were, two round holes six feet deep and seven feet diameter were made; the railway station, forty yards off, was blown to pieces. The whole valley at the foot of Snowdon and two large lakes suffered a severe shock, the damage done all round the valley being very great. The shock was felt at Bangor, which is about nine miles from the scene of the accident. There has been, of course, hardly time for details yet, but up to the time of our going to press it has been ascertained that four deaths had resulted from the explosion, and that twelve persons were severely and seven slightly injured. An investigation into the cause of the explosion was opened yesterday and adjourned. We shall have more to say on this matter in our next.

Eclipse Notes.—Determining “First Contact” with the Spectroscope.—One of the most beautiful observations made during the late eclipse was that of Prof. C. A. Young, on the first contact, by means of the spectroscope. Our readers are, no doubt, familiar, from former notices, (as on p. 87 of Vol. LVII.), with the method developed by Lockyer, of viewing solar prominences in the spectroscope without the aid of an eclipse. Prof. Young, as will be seen from his note, (p. 141 of our last number,) has been giving much attention to this subject, and has fitted up a very efficient instrument for the purpose.

During the eclipse of last month, he was stationed at Burlington, Iowa, and shortly before the first contact was due, he found that there was a solar prominence located at the spot where first contact must occur. (See F in cut on page 210.)

He therefore fixed his spectroscope with the slit radial to the solar edge at this point, so getting a prominence spectrum whose width was determined by the height of the prominence. Closely watching this, he presently found that it began to narrow steadily, and at the instant that it became a mere line and disappeared, he recorded first contact.

From the first photograph showing contact made by the Phila-

delphia party at the same place, Prof. A. M. Mayer, who had charge of that division, calculated the time of actual first contact, and found that it came within two-tenths of a second of the record made by Prof. Young.

Spectrum of the Corona.—During the totality of the late eclipse, Prof. Young gave special attention to observation of the corona with the spectroscope.

He found, that in place of a subdued solar spectrum which would have been anticipated from the reports of former observations, it yielded a spectrum of bright lines. The most prominent of these he was able to measure, and found its position as that indicated by 1474 on Kirchhoff's chart. Two other fainter ones were noticed, but there was no time to measure them. Prof. Young writes us, that he finds, by graphical projection, a close correspondence between this principal corona line and the brightest of the aurora lines observed by Prof. Winlock, on the 15th of April, and indicated by him as occupying the position of 1550 on Huggins' chart. Prof. Young also considers that the two fainter corona lines observed, but not measured by him, correspond with aurora lines 1280 and 1400 of Huggins' chart, observed by Prof. Winlock, on the occasion above noticed.

From these observations, Prof. Young hazards the conjecture that *the solar corona is, in fact, a permanent aurora.*

The Corona not Polarized.—With the above observations and deductions made by Professor Young, agree exactly those which were made at Mount Pleasant, Iowa, by Professor E. C. Pickering, who with a spectroscope observed no dark lines in the general light from the total phase, and with a polariscope arranged on the plan used by Arago in his study of sky—polarization, found no trace of this condition in the light from the corona. Professor Pickering's report in full will appear in our next number, and will contain a very ingenious and interesting discussion of these and other observations.

Solar Prominences as seen and as Photographed.—It will be remembered that in De La Rue's photographs in 1860, several prominences were conspicuously depicted which were not seen by any of the observers. This no doubt results from the great difference in actinic force between the light from the corona and prominences, when compared with their luminous intensity, the corona appearing intensely bright, but being very feeble in actinic effect,

while many of the prominences present an inverse order of the same properties. On the occasion of the late eclipse, the same thing was remarked, and when drawings and photographs come to be compared, this will be made manifest. We have already received some general information, from which it would appear that at the points marked B and C on the woodcut, p. 210, and shown on the photographic illustration in corresponding positions at either side of the spindle or ear of corn, only two pyramidal masses of white light, tipped with rose color, were seen, and that at F appeared a body having the shape of a mushroom, of a delicate rose color above, and white below.

Meteoric Shower During the Eclipse.—On p. 213 of this number, will be noticed some observations made by the Philadelphia party at Ottumwa, Iowa, bearing on this subject, and from Professor J. H. C. Coffin, U. S. N., we have just heard that Mr. Chas. G. Boerner at Vevay, Ind., reports "several metcors were seen (during the eclipse), about 45° above the horizon, their path being in a westerly direction." Professor Coffin himself noticed the passage across the telescope from east to west, of several bright flakes resembling thistle blows floating in the sunlight, and yet so well defined that they must have been distant.

Solar Prominences.—In a late lecture at the Royal Institution Mr. Lockyer said as follows:—

"Although I find it generally best for sketching purposes to have the open slit in a radial direction, I have lately placed it at a tangent to the limb, in order to study the general outline of the chromosphere, which in a previous communication I stated to be pretty uniform, while M. Janssen has characterized it as '*a nireau fort inegal et tourmente.*' My opinion is now that perhaps the mean of these two descriptions is, as usual, nearer the truth, unless the surface changes its character to a large extent from time to time. I find, too, that in different parts the outline varies: here it is undulating and billowy; there it is ragged to a degree, flames, as it were, darting out of the general surface, and forming a ragged, fleecy, interwoven outline, which in places it is nearly even for some distance, and, like the billowy surface, becomes excessively uneven in the neighborhood of a prominence. According to my present limited experience of these exquisitely beautiful solar appendages, it is generally possible to see the whole of their structure; but sometimes they are of such dimensions along the line of sight that they

appear to be much denser than usual; and as there is no longer under these circumstances any background to the central portion, only the details of the margins can be observed, in addition to the varying brightnesses. Moreover, it does not at all follow that the largest prominences are those in which the intensest action, or the most rapid change, is going on,—the action as visible to us being generally confined to the regions just in or above the chromosphere, the changes arising from violent uprush or rapid dissipation, the uprush and dissipation representing the birth and death of a prominence. As a rule, the attachment to the chromosphere is narrow and is not often single; higher up, the stems, so to speak, intertwine, and the prominence expands and soars upward until it is lost in delicate filaments, which are carried away in floating masses.

"Since last October, up to the time of trying the method of using the open slit, I had obtained evidence of considerable changes in the prominences from day to day. With the open slit it is at once evident that changes on the small scale are continually going on; it was only on the 14th inst., that I observed any change at all comparable in magnitude and radidity to those already observed by M. Janssen. About 9 hrs. 45 min. on that day, with a tangential slit I observed a fine dense prominence near the sun's equator, on the eastern limb. I tried to sketch it with the slit in this direction; but its border was so full of detail, and the atmospheric conditions were so unfavorable, that I gave up the attempt in despair. I turned the instrument round 90 degrees, and narrowed the slit, and my attention was at once taken by the F line; a single look at it taught me that an injection into the chromosphere and intense action were taking place. At 10 hrs. 50 min., when the action was slackening, I opened the slit; I saw at once that the dense appearance had all disappeared, and cloud-like filaments had taken its place. The first sketch, embracing an irregular prominence with a long perfectly straight one, which I call A, was finished at 11 hrs. 5 min., the height of the prominence being 1 min. 5 sec., or about 27,000 miles. I left the observatory for a few minutes, and on returning at 11 hrs. 15 min., I was astonished to find that part of the prominence A had entirely disappeared; not even the slightest rack appeared in its place; whether it was entirely dissipated, or whether parts of it had been wafted toward the other parts, I do not know,

although I think the latter explanation the more probable one, as the other part had increased."

Mr. Lockyer threw a fine picture of this storm in the sun upon the screen.

On the Means of entirely Preventing Bumping of Liquids while Boiling.—M. E. Winkelhofer.—The author reviews what has been done by others, and especially by Dr. Pellogio, and next describes, at length, some experiments of his invention, embracing the following fluids:—Methyl-alcohol, sulphuric acid, alcoholic solution of sulphate of protoxide of iron, alcoholic potassa solution, hydrochloric acid and dilute sulphuric acid, containing some sulphate of lead. His plan, to prevent bumping, is simply an electric current, led into the fluids by means of suitable conducting wires; his contrivances are very ingenious, but certainly too complicated for general use.

The Water of the Grenelle Artesian Well.—M. Stoelet calls attention to the remarkable fact that this water does not contain any dissolved oxygen, but only nitrogen, the quantity of which amounts to 14 c.c. to the litre of the water at 10° C. The total saline residue to the litre amounts to 0.142 grm.; the percentage composition of this saline matter is:—Carbonate of lime, 40.8; carbonate of magnesia, 11.5; carbonate of potassa, 14.4; carbonate of protoxide of iron, 2.2; sulphate of soda, 11.3; hyposulphite of soda, 6.4; chloride of sodium, 6.4; silica, 7.0. The same author has estimated the quantity, and determined the quality of the gases contained in rain-water fallen and collected in the neighborhood of Paris; 1 litre of this water gave 23 c.c. of gas composed, in 100 parts, of 2.4 parts of carbonic acid; the remainder was a mixture of oxygen and nitrogen, in the proportion of 32 parts of the former to 68 of the latter. M. Stoelet has discovered that the water brought up from the coal-pits contains a greasy matter, soluble in ether, and no doubt derived from the coal; from his observations at and about collieries, he draws the conclusion that this greasy or fatty matter makes the water unsuitable, and at times, even dangerous, for the use of steam boilers, since it may cause explosions.

Climate of the Isthmus of Suez.—Referring to this subject, M. Le Verrier read an abstract of a letter from Prof. Buijs-Ballot, the Director of the Royal Netherlands Meteorological Institute at Utrecht, wherein that gentleman states that the draining of the Harlem lake, in Holland, a surface of 19,000 hectares, has had the

effect of increasing the average summer temperature of that locality, and adjacent country, by $\frac{1}{2}^{\circ}$, and of decreasing the average winter temperature, also, by $\frac{1}{2}^{\circ}$ C.

Very Durable Cement for Iron and Stone.—M. Pollack, of Bautzen, Saxony, states that, for a period of several years, he has used, as a cement to fasten stone to stone, and iron to iron, a paste made of pure oxide of lead, litharge and glycerine in concentrated state. This mixture hardens rapidly, is insoluble in acids (unless quite concentrated), and is not affected by heat. M. Pollack has used it to fasten different portions of a fly-wheel with great success; while, when placed between stones, and once hardened, it is easier to break the stone than the joint.

Improvement of Acid Waters often Pumped up from Coal-Pits and Mines.—Dr. Willigk.—The author had an opportunity to analyse a water pumped up from a coal-pit in Bohemia. This water, it appears, was very acid, from acid sulphates and some free sulphuric acid present therein, consequently attacking and corroding the pumping gear and machinery, and seriously affecting the steam boiler wherein it had to be used. No other feed-water being on the spot, the author advised, and with good success, that the water should, previous to use, be filtered over witherite, carbonate of baryta, which happened to be abundantly present in that locality.

Volumetrical Estimation of Sulphuric Acid.—Dr. A. Clemm.—After reviewing the methods of R. Wildenstein and Carl Mohr, applied for this purpose, the author describes his mode of operating at length. Briefly stated, his method is the following:—The solution to be experimented upon is colored with litmus, and very carefully neutralised; a solution of chloride of barium of known strength is added in excess, and all the sulphuric acid thereby precipitated. Next, a titrated solution of carbonate of soda is added, in order to precipitate the excess of baryta; and next, again, the excess of soda solution used is estimated, volumetrically, by means of a titrated dilute sulphuric acid. During these operations, no salt is formed which can injure the color of the litmus. In case salts might be present in the original solution, the bases of which could be precipitated by carbonate of soda, that precipitation is performed previous to the addition of soda. The filtrate, which contains the sulphuric acid combined with soda, is neutralised, and again volumetrically titrated. The solutions required for this experiment are:—A solution of chloride of barium, containing 52

grms. to the litre of water; a solution of carbonate of soda, containing 26.5 grms. of this salt to the litre of water; a solution of sulphuric acid, containing 20 grms. of strong sulphuric acid to the litre of water. These solutions agree among each other, drop for drop. The advantage claimed for this method is the non-necessity of having to wash out the sulphate and carbonate of baryta, and also the advantage that titration does not take place in a fluid rendered turbid by therein-suspended sulphate of baryta, which always tends to render the observation of coloration of litmus more difficult.

Testing Chloroform for the presence of Alcohol and Ether.—The chloroform should be first treated with fused chloride of calcium, to eliminate any water, next some iodine should be added. If the chloroform is free from either alcohol or ether the color produced by the solution of the iodine is bright red; but when either alcohol or ether are present, the color of the solution is brown. In order to distinguish between alcohol and ether, a small piece of a crystal of fuchsin is added to the chloroform in question; when the slightest trace of alcohol is present, a deep red solution will ensue. Perfectly pure chloroform yields, with fuchsin, a solution which is only slightly pinkish tinged.

Salt Deposit near Berlin.—M. Jahn.—It appears that there has been discovered near Berlin, at Sperenberg, a rock salt deposit, which in some localities has a thickness of 669 feet. The locality where this important discovery has been made is within eight miles of the capital city of Prussia, and, from borings instituted, it appears in every respect, a highly valuable mineral deposit.

Sensitiveness of Divers Methods for the Detection of Arsenic.—M. Frank.—Marsh's apparatus admits of detecting 0.0003 milligramme AsO_3 , dissolved in 150,000,000 of its weight of liquid; the method of Von Babo and Fresenius admits of detecting 0.002 milligramme AsO_3 ; Reinsch's method, by means of copper, detects 0.001 milligramme AsO_3 , in 5,000,000 as much liquid; Rieckher's method, by means of ammoniacal nitrate of silver solution, detects 0.002 milligramme in 3,000,000 parts of liquid.

Use of the Spectroscope to Distinguish a Feeble Light, Present with a Stronger Light.—M. Seguin.—The author describes a series of experiments with electric light, and observations thereon with Duboscq's vertical spectroscope. The result and conclusion arrived at is, that the spectroscope serves eminently the purpose of detecting (proved also by the other observations made

with it of the sun's light and protuberances) a more feeble light present with a much stronger, and the former of which would be invisible to the naked eye, or by means of other optical instruments.

Palladium and Hydrogen.—M. Fevre states that, according to his experiments, the hydrogen in palladium saturated therewith, is present as a chemical compound, and not simply in the state of condensed gas. The author also states that the vapor of boiling mercury is as little a conductor of electricity as hydrogen and that, therefore, the non-conductibility of hydrogen for electricity cannot be regarded as an objection to its being a metal.

Radiation of Heat from the Moon.—The Earl of Rosse is making a series of experiments by means of a thermo-pile of four elements and a 3-foot telescope, to determine, if possible, what proportion of the moon's heat consists of: 1. That coming from the interior of the moon, which will not vary with the phase; 2. That which falls from the sun on the moon's surface, and is at once reflected regularly and irregularly; 3. That which falling from the sun on the moon's surface is absorbed, raises the temperature of the moon's surface, and is afterwards radiated as heat of low refrangibility. The chief result arrived at up to the present moment is, that (the radiating power of the moon being taken as equal to lampblack, and the earth's atmosphere supposed not to affect the result) a deviation of 90° for full moon appears to indicate an elevation of temperature = 500° Fahr. The relative amount of solar and lunar radiation was found = 89819 : 1.

Action of Sunlight on Mineral Oils.—Some curious experiments, recently made by Herr Grotowsky, on the action of sunlight upon mineral oils, show that when the different kinds of petroleum oils are exposed to the influence of sunlight, they absorb oxygen from the air and convert it into ozone, as has been shown already for many other hydrocarbon oils by Shoenbein, Kuhlmann, and Phipson. According to Professor Grotowsky, no chemical combination occurs between the oil and the ozone; the latter remains free, and oxidizes powerfully any substances brought into contact with it. The odor of the oils is completely modified when they contain ozone;—the author states that they cannot be burnt, and that they rapidly attack cork. The color of the glass bottles in which the oils experimented on are enclosed, has a marked influence on this absorption of oxygen. Preserved in iron vessels, or completely out of the rays of daylight, all these oils may be pre-

served intact; but in white glass jars exposed to the light, the white oils become yellow, are highly charged with ozone, increase in specific gravity 0.005, burn with much difficulty, and attack the corks of the bottles. This is particularly the case with American petroleum.

Physiological Effects of Compressed Air.—Dr. G. von Liebig has made some new experiments on this subject, and concludes, 1. That the number of inspirations and expirations in an atmosphere submitted to a high pressure, when the animal has become accustomed to it, does not differ much from that which occurs in ordinary circumstances. 2. That the quantity of air breathed is not very different. 3. That the quantity of carbonic acid evolved is nearly identical in both cases.

Oxygen Developed without Heat.—Böttger, who devised the process, takes equal weights of peroxide of barium and peroxide of lead, and having mixed them together, adds some very weak nitric acid. Active effervescence immediately commences, and it is found that the gas evolved is pure oxygen. It will be seen that, according to Schönbein's theory, one of the peroxides employed evolves ozone, and the other antozone, or oxygen in the positive and the negative states, and these combine as they are given off to form neutral or ordinary oxygen. This process is of more scientific than practical interest; but it may be useful perhaps when small quantities of oxygen are required for medicinal purposes.

Bronzing Process, applicable to Porcelain, stoneware, and composition picture and looking-glass frames. The articles are first done over with a thin solution of water-glass by the aid of a soft brush. Bronze powder is then dusted on, and any excess not adherent is knocked off by a few gentle taps. The article is next heated, to dry the silicate, and the bronze becomes firmly attached. Probably, in the case of porcelain, biscuit, or stoneware, some chemical union of the silicate will take place, but in other cases the water glass will only tend to make the bronze powder adhere to the surface. After the heating, the bronze may be polished or burnished with agate tools.

Ventilation.—Gen. Morin, in giving an account at the Académie des Sciences of the successful application of his ventilating apparatus in a large weaving factory employing 400 work people, and in which were lighted 400 jets of gas, observed that its advantage might be judged of from the fact that during October, November,

and December, 1867, when the ventilation was defective, only 15,000 kilogrammes of bread were consumed, while, during the same months of 1868, after it had been improved, 20,000 kilogrammes were required, being a gain of 25 per cent. for the health and vigor of the operatives.

The Oxyhydrogen Light scheme has now taken a definite shape in Paris. A company has been formed, the capital necessary has been raised, and application has been made for permission to lay down pipes to carry oxygen and hydrogen over about a fourth of the city. It is not very likely that the permission will be granted, and the promoters will have to confine themselves to supplying individuals with compressed gases, as was originally proposed. We have published the patented processes by which M. Tessié du Motay obtains the oxygen and hydrogen which he proposes to distribute over Paris, at a cost so low that the oxyhydrogen light is promised much cheaper than common gas light; but ingenious and relatively cheap as they undoubtedly are, it is impossible to believe that the service can be made so inexpensive as to supersede coal gas. The prospectus of the company enlarges upon the cheapness and purity of the light, the complete combustion, and the absence of all deleterious matters in the products of the combination; but is quite silent as to the danger of introducing into a house two gases not possessing any smell, and which, consequently, may escape without observation, and the mixture of which forms an explosive compound of far greater power than any mixture of coal gas and air. To any danger of this kind, continental engineers appear to shut their eyes. We saw, a short time ago, a patent taken out in Belgium for making a mixture of coal gas and air, storing it in gas holders, and distributing it over the city of Brussels for heating purposes. The engineering details given showed a complete knowledge of the subject of the manufacture and distribution of gas, but there seemed to be no recognition of the risk, imminent enough, of blowing up the whole concern. A consideration of this kind, some years ago, stood in the way of a scheme of the kind projected for Birmingham, and will, no doubt, prevent the Oxyhydrogen Light Company from getting permission to lay down their pipes over Paris.

Ozone.—The information comes all the way from Tiflis, in Persia, that peroxide of hydrogen has been discovered in the air. Schönbein, who had no doubt of its existence in the atmosphere, never suc-

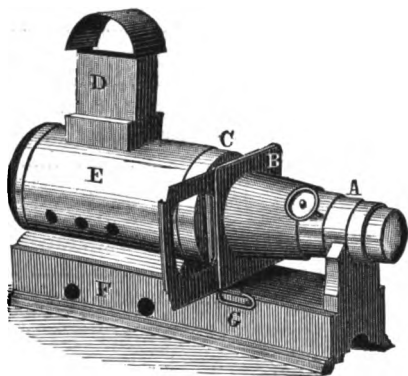
ceeded in demonstrating its presence. This success, however, is claimed by M. Struve. Along with the peroxide of hydrogen, the discoverer always finds ozone and nitrate of ammonia. These were also found in hail and in sea water. In these days, when the origin of nitrates of water is so warmly debated in connection with the question of the possible prevention of sewage contamination of water, we are fortunately reminded by M. Deville of the fact that he collected snow on the Andes, at the height of about 15,000 feet, which yielded a large amount of nitric acid, doubtless derived from nitrite of ammonia, which Struve has now discovered in the air.

Cornish Pumping Engines.—The number reported for May is 18. They have consumed 1,377 tons of coal, and lifted 10·2 million tons of water 10 fathoms high. The average duty of the whole is, therefore, 50,100,000 pounds, lifted one foot high, by the consumption of 112 pounds of coal.

Marcy's Improved Magic Lantern.—Our attention was drawn some time since to this very decided improvement in lanterns illuminated by ordinary flames, by which their efficiency is so greatly increased that many results can be reached which were heretofore only attainable by aid of the lime or magnesium lights.

The most important feature in this apparatus is the lamp, or as it might in this case be called from its appearance, the furnace.

This source of action to the entire machine is placed in the cylindrical chamber *E* and provided with the chimney, *D*, and has two flat wicks one and a half inches long, parallel to each other and to the axis of the chamber, and in fact the optical axis of the instrument. The flames or rather sheets of flame that rise from these wicks



are drawn together by the arrangement of the draft, and so form a pointed ridge or edge of intense light in the axis of the condensers, which are placed at *C*. We have on various occasions alluded to the fact long ago pointed out by Rumfort that flame was practically transparent. Here this property is utilized, and by reason of it we can get through the

condenser all the accumulated brightness of the long line of light, one and a half inches deep.

We have witnessed a number of experiments with this lantern, and can fully endorse it, as a great advance upon anything before used in the shape of a lamp-illuminated magic lantern.

For a parlor or school exhibition, it may well take the place of the far more troublesome oxycalcium lantern, which it rivals in efficiency.

There are many details of construction which are of very ingenious and efficient character, among which we would specially notice the slide for pictures, by which, one picture being in use, another may be removed and exchanged, and then by a single movement brought into the field, while the other is in like manner ready for substitution.

Analysis of the Hathorn Spring Water.—Professor O. F. Chandler, of the School of Mines, New York, has analyzed the water of Hathorn Spring, and certifies to the following solid contents found in a cubic gallon of water:—

Chloride of Sodium.....	503.968 grains.
Chloride of Potassium.....	9.597 "
Bromide of Sodium.....	1.534 "
Iodide of Sodium.....	.198 "
Fluoride of Calcium.....	a trace.
Bicarbonate of Lithia.....	11.447 "
Bicarbonate of Soda.....	4.288 "
Bicarbonate of Magnesia.....	176.463 "
Bicarbonate of Lime.....	170.646 "
Bicarbonate of Strontia.....	a trace.
Bicarbonate of Baryta.....	1.737 "
Bicarbonate of Iron.....	1.128 "
Sulphate of Potassa.....	none.
Phosphate of Soda.....	.006 "
Biborate of Soda.....	a trace.
Alumina.....	.131 "
Silica.....	1.260 "
Organic matter.....	a trace.
Total solid contents.....	888.408 inches.
Carbonic acid gas in one gallon.....	875.747 "
Density.....	1.009 "

The Borings for Rock Salt near Wylen, Switzerland, have given very favorable results. Near the Rhine, a bed of 80 feet in thickness has been found at a depth of 420 feet below the surface, and another 50 feet thick not far off. The salt is hard, pure, and of excellent quality.

Civil and Mechanical Engineering.

BELTING FACTS AND FIGURES.

By J. H. COOPER.

(Continued from page 109.)

Pulleys with Leather Covering.

"THE sliding or slipping of belts on the pulleys is an evil experienced by almost every one whose business depends on machine power. Various means have been devised to avoid it. One of them is to strew powdered rosin or pitch on the inside of the belt. Another is to cover the pulleys with wood. A third is to give the rim of the pulley a curved surface. These means are only palliatives, and lack a thorough, steady and continued action. Rosin and pitch are soon pressed into the leather, when they not only lose their efficacy, but contribute to the rotting and destruction of the belts. A wood covering on the pulley gets polished in a short time, and is then as slippery as iron. It is therefore necessary to frequently roughen its surface, by which operation the diameter of the pulley is diminished, and the proportions of the transmission are altered. A convexity of the rim of the pulley is very effective to prevent the dropping off of the belt, especially when the pulley has a horizontal position; but it counteracts the slipping of the belt to but a small extent.

"We therefore take pleasure in communicating to the public a mechanical contrivance, which completely prevents the sliding of belts and all the great disadvantages resulting from it. It consists in covering with leather the working surface of the pulleys. As the friction of leather on leather is equal to five times that of leather on iron, and as leather can be roughened and be easily kept in that condition, it is evident that a sliding of the belts cannot take place on pulleys covered with leather, not even when the belts have to transmit the very highest amount of power. We have seen such pulleys working in sugar factories, breweries, in manufactories of German silver, in paper mills, machine shops, sawing mills, and in many other mechanical establishments, in all of which they have proved of eminent usefulness and great practical value.

With pulleys which have to run at a great velocity, as, for instance, those which drive blowers and saw-frames, as well as with pulleys of small diameter, which transmit powerful strains, the advantages of a leather covering are especially great. But besides these evident advantages resulting from the avoidance of the slipping, a leather covering on the pulley preserves the belt; in the first place, because the belt does not require tightening so hard, the friction being considerably increased; and in the second place, because there is no occasion for a rapid rotting of the belt. For this rapid rotting is generally caused by the fact, that under the influence of the heat produced by friction, the tannic and sebacic acids contained in the leather of the belts, combine chemically with some of the iron of the pulleys, forming a hard compound in the belts, which produces what is called rottenness, and frequently causes breakages. This evil is of course avoided by covering the pulleys with leather.

* * * * *

"The coverings are fixed to the pulleys by a kind of paste or glue, which hardens in a very short time, and sticks so well to iron and leather, that the greatest forces can be transmitted by the pulleys without loosening the leather. The operation of covering is very simple, and can be done and renewed by every intelligent workman. The price is 1½ Prussian thalers per square foot of leather, including the glue."—Translated from *Polyt Centralblatt*. From Van Nostrand's *Eclectic Engineering Magazine*, July, 1869, p. 604.

To fasten Leather to Metal.

"A. M. Fuchs, of Bairère, says that in order to make leather adhere closely to metal, he uses the following method:—The leather is steeped in an infusion of gall nuts; a layer of hot glue is spread upon the metal, and the leather forcibly applied to it on the fleshy side. It must be suffered to dry under the same pressure. By these means, the adhesion of the leather will resist moisture, and may be torn sooner than be separated from the metal."—*Athenæum*.

Blake's Patent Belt Studs.

This approved device for fastening rubber and leather belting was patented April, 1860, and March, 1861, and re-issued August, 1868. Messrs. Greene, Tweed & Co., 10 Park Place, New York, have the sole right to make and sell this invention, and during the

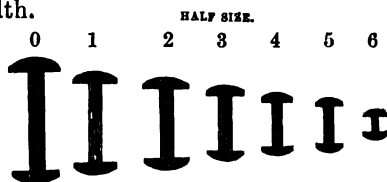
last four years have supplied the studs to over ten thousand manufacturing concerns in the United States.

They are recommended to be better and cheaper than either lacing or hooks. When the above mentioned studs for fastening the ends of belts were tested on a 6-inch 4-ply rubber belt, the following result was obtained:—

Belt hooks tore out under a strain of.....	800 pounds.
Lacing " " "	1690 "
Blake's studs held up to "	4600 "

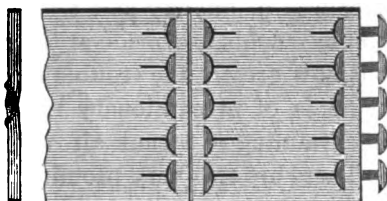
Where lacing or other methods of fastening are used, requiring punched holes, which weaken the material of the belt, the whole strain transmitted by the belt must be carried by a width section of the belt less by the sum of the diameters of the holes, which in usual practice is about one-third the width of the belt, whereas by the use of the patent studs, no punched holes are made, the material of the belt is not reduced, and nearly the whole section is available for strain, the stud being of such a form and inserted in such a manner as to grip nearly its entire width.

Belts fastened by studs, are running now nearly four years, without repair. The ends of the belts are kept close together, and the studs do not touch the pulleys.



When belts have become too rotten to hold lacings, they can be fastened with these studs, which will hold until the belts are completely worn out. For damp places, these studs make a secure fastening.

In fastening the belts by these studs, the slit in a leather belt should be a $\frac{1}{4}$ inch, and in a rubber belt $\frac{3}{8}$ inch from the ends, and the studs inserted $\frac{1}{2}$ inch apart.



The cuts above give the form of the studs, the sizes made, and their position in the joint.

The smallest size is used for sewing machine belts, and the like, the next size say for 2-inch belts, and the largest for 4 and 5-ply rubber and double leather belts.

(To be Continued.)

LAYING CULVERTS UNDER THE BEDS OF RIVERS AND CANALS.

THERE is always more or less hazard and risk in disturbing what may be called the "existing state of things." Nevertheless, it becomes imperatively necessary, on certain occasions, to incur the risk of so doing. Of all the examples of engineering practice, in which a corroboration of this statement is to be found, that relating to interfering with the *status quo* of the beds and banks of rivers and canals affords the most conclusive one. Numerous have been the accidents and dire the consequences of excavating even in the approximate locality of these situations. It is impossible to observe too much caution in conducting operations of this nature, which have now become more frequent than formerly. This is partly owing to the fact that rivers are no longer regarded as inseparable barriers between their opposite shores, and that attention has, during the last few years, been prominently drawn to the practicability of effecting a communication underneath instead of overhead. This has been exemplified on a gigantic scale by the proposed submarine communication between England and France, and is being practically carried out by the Waterloo and Whitehall Pneumatic Company, and by the construction of the subway under the Thames at the Tower. Although not arrived at this pitch of subfluvial tunnelling, the French have accomplished something in that line, by the large syphon tube recently successfully laid under the Seine, to connect the sewage channels on each side of that river. The laying of culverts and pipes under embankments has always been a source of anxiety and trouble to the engineer, even when the embankments are made at the same time. It is needless to point out how greatly the trouble increases, and how much greater need there is of precautionary measures, when the case involves the undermining of a bank already *in situ*.

There are two very prominent instances to be adduced where the laying of pipes and culverts underneath the banks of water reservoirs were attended with leakage and bursting. The one is the well known catastrophe at Bradfield, some few years ago. The other is the leakage and subsequent emptying of the Vartry reservoir, constituting a portion of the Dublin Water Works. Whatever might have been the true cause of the former mishap, whether it was due to an error in the principle of construction adopted, or in practical working defects, there is very little doubt about the

latter. The extrados of the arch of the culvert was left nearly smooth, without any offsets, steps, or "racking-back," to afford a firm hold of the puddle of the bank. In fact, there was really a straight joint between the puddle and the masonry, whereas there should have been a union as intimate as it was possible for ingenuity to imagine. As might be expected, the water found out the "weak spot." The result was the emptying of the reservoir, which had taken months to fill, and the plunging of the Dublin Corporation into litigation, which entailed upon it a large amount of expense. In many of the towns where new sewage works are in course of construction, it has been necessary to lay iron pipes below the beds of the adjoining rivers and canals, both for the purpose of effecting a communication between the sewers upon the opposite sides, and also, in some instances, to constitute a channel of conveyance for the sewage to the fields intended to be irrigated. This subaqueous plan has been adopted at Norwich, where very extensive drainage and sewage works are in progress. Some idea of their extent may be gained from the fact that they are estimated to cost £60,000. Provided the foundation be good, and concrete be used liberally, the only point presenting much difficulty is the joints, which sometimes give a great deal of trouble. The depth to which the drains must be sunk depend, in the first place, upon the levels; and, secondly, upon the condition of traffic in which the river is placed. If the river be navigable, and used for the purposes of navigation, the pipes should not be placed too near the surface, and should be well protected, especially about the joints, with cement concrete, or they are liable to be damaged by the anchors of boats. Were there any choice in the matter, it would always be preferable to take the drain or pipe over instead of under the river, but it is seldom that the levels are so entirely optional as to afford the right of selection.

An instance of the bursting of a canal embankment, in consequence of excavating underneath it, for the purpose of constructing a culvert, occurred a very short time ago. It appears that a portion of the embankment of the Napton and Warwick Canal, on the Warwick side of the river, was washed away. The breach made was nearly forty feet in width, and the water escaping through it with great velocity completely inundated the adjoining fields, and did a great deal of mischief to the young crops and property. Although the conclusion is not absolutely an infallible one, that

the proposed construction of the sewer was the cause of the accident, yet, when it is borne in mind that the excavation was carried on in close proximity to the breach, it is difficult to trace the effect to any other cause. As a rule, we should prefer in these hazardous situations to lay cast iron pipes instead of building a culvert. The time which the disturbance and interference with the existing bank occupies is of equal importance with the nature of the operations carried on. A much shorter time will suffice to lay in a pipe than to construct a culvert of brick-work or masonry. The former will also require less excavation than the latter, for supposing them to have the same internal dimensions, the arch, invert, and side walls of the culvert, will necessitate the taking out of a considerable additional quantity of earth. These proportions in a cast iron pipe are simply its thickness, which practically is inappreciable. Besides, an increase in the capacity or internal size of the pipe, produces little or no corresponding difference in the thickness. With the exception of the difficulty sometimes experienced in making good the joints, there is no comparison with respect to the relative facilities of the two methods for establishing a speedy and secure communication between the opposite banks. The manner in which the canal is constructed, at the place where the intended pipe or culvert is to cross, has a very great effect upon the risk attending its successful laying. Should the canal be carried altogether in an embankment, and the levels not permit of the pipe being laid in the natural ground, but require it to be placed in the artificial bank, the danger is seriously augmented. Not only is the foundation more treacherous and insecure, but the earth above is more liable to subside than if it consisted of a thin stratum of the natural surface. Subsidence is not necessarily a forerunner of leakage or bursting, but it frequently does precede those serious contingencies, and may be regarded as a warning sign which should never be disregarded. A distinction must be drawn here between the ordinary subsidence, which invariably follows the erection of every new bank, a short time after its construction, and that for which there is no apparent cause. The former is always expected, and provision made accordingly for raising the bank to its proper level. The latter should be at once carefully inquired into, and a constant watch set on the spot.—*Mechanics' Magazine.*

THE BINGLEY EXPLOSION.

THE fatal boiler explosion at Bingley, which caused the death of fifteen persons, and injured about twenty-five more, has been the subject of investigation by Mr. L. E. Fletcher, Engineer-in-Chief to the Manchester Steam Users' Association. The examination was made at the instance of the coroner, who very judiciously adjourned the inquest pending Mr. Fletcher's report. That document has now appeared, and, from a perusal of its contents, it appears to us miraculous how the boiler lasted so long as it did. It was of the type usually employed in the Lancashire and Yorkshire mills, but was constructed of inferior metal, and so was wrong from the first. Previously to being put to work at Bingley, it had seen some eight or nine years' service in another establishment. When it left the latter place, it was purchased by a boiler maker, repaired, and re-sold. The repairs were necessitated by external corrosion underneath the boiler, but they were imperfectly done. Half-inch plates were riveted on to the old plates where they had become worn to a quarter of an inch. Thus patched up, the boiler lasted three years, when it exploded with the fatal effects we have mentioned. From an examination of the fragments, Mr. Fletcher found that leakage began at the junction of the old and new work. In more than one place, the plates were found to be reduced to the thickness of a sheet of paper—the old, old story. Of course, the shell gave way here, and the rent proceeding thence through the adjoining plates, soon completed the destruction of the boiler.

But the piece of patchwork was not the only fault the boiler had; it was badly equipped, and badly tended as well. The safety valve was too small and of defective construction, and the engine tender is believed to have been both incompetent and reckless—two conditions generally found associated together. Mr. Fletcher, however, very properly observes that some more practical lesson should be drawn from this fatal catastrophe than to throw the onus of fifteen deaths upon an ignorant stoker already killed by the explosion. The jury, however, returned a verdict of manslaughter against the dead stoker, and censured the owners of the mill for employing so incompetent an attendant and leaving him without supervision. They also recommend that all boilers should be brought under government inspection, and there the matter rests. But the circumstances attending the construction and use of this boiler call

for further remark here. We have over and over again pointed out how really preventable are those explosions, and that, therefore, they do not properly come within the meaning of the term "accident." It is needless to observe that this boiler was not under inspection, or it would have been condemned three years since. Had it been properly constructed at first, and placed under the protective inspection of one or other of the companies formed for this purpose, it is highly improbable that the recent catastrophe could have occurred. To guard against the possibility of bad material, Mr. Fletcher suggests that the plates used in the construction of boilers should not only be branded or stamped, like silver, with a certificate of quality, but marked also with the name of the manufacturer, so that the responsibility of the work could always be brought home to him. Then, with regard to the fittings, we all know how easy it is to meet ignorance or foolhardiness by safety valves of proper construction. In short, the Bingley explosion is only a repetition of an oft-told story, which must lead to protective legislation if repeated in the highly culpable form it has here assumed. Such events make us look with anxiety to the work the Committee of the Manchester Steam Users' Association have taken in hand, for promoting the security of life and property against unsound boilers. They propose that coroners should be empowered and instructed to command the attendance of competent engineers to give evidence when conducting inquiries in reference to these disasters. This would render unnecessary any government action, which might prove an interference with the freedom of the steam user, but to which he will inevitably have to submit if he does not mend his ways.

Road Watering.—All lovers of fair play will be glad to hear that Mr. Cooper's system of laying the dust by means of a solution of certain salts, is now in full and successful operation in Liverpool, with the cordial coöperation of the local authorities. Thanks to the inefficient supervision exercised by the Marylebone vestry, over the ignorant and interested servants whom they appointed overseers during Mr. Cooper's contract, and the consequent persecution and pecuniary loss to which that gentleman was subjected, there will be little chance of improvement for our metropolitan roads just at present. In Liverpool it is found that 75 per cent. of the work of water distribution is saved, but probably the most interesting fact elicited is that in streets watered on Mr. Cooper's system, sweeping may be practically dispensed with. This is a result worth noting.

THE LONDON WATER SUPPLY.

IT is more than two years and a half since the Committee appointed to examine into the condition of the Metropolitan Water Supply commenced their labors but recently terminated, these being recorded in a report, the conclusions of which we have already published. The probable future metropolitan water requirements, and whether the source whence its present supply is derived will be sufficient and reliable in all ways for the coming generations, or whether we should begin to look elsewhere than to the Thames Valley for our main supply, were the questions which the Committee had to set themselves earnestly to consider, and, judging from the voluminous evidence they have received, from the personal examinations they have made, and from the care with which they have weighed evidence and studied the physical peculiarities of the basins of the Thames and of the Lea, we are bound to assume that their recommendations are correct, and that the Thames and the Lea, which have hitherto supplied London with water, will never fail, either in quantity or quality, in serving the metropolitan demand, even though it should grow and extend itself in a proportion which the increase of the decades of the past does not warrant in assuming for the future.

Two hundred millions of gallons of water a day is estimated as the future necessary supply for a population swelled to 5,000,000; nearly 200,000 tons of water distributed over an area of 224 square miles, through mains and branches and service pipes to meet individual demands, or public wants;—forty gallons being apportioned to each unit of the 5,000,000 every day. Times are changed, and necessities have increased since the city ran with sparkling streams from the high lands on the north of London, and carried a plentiful supply, which could be had for fetching: or since the local springs were collected and led by conduits through the city. The streams have long since disappeared, changed into sewers, arched over out of sight, and nothing but the names are left of the conduits to mark the course along which they ran. But these supplies were too limited even for London of the sixteenth century, and three hundred years ago came Peter Morrys, the Dutch engineer, who utilised the constant flood pouring through the narrow archways between the piled-up starlings of old London Bridge, to drive pumps that

raised water and supplied, by wooden mains and by open gullies, the neighboring streets for two centuries after his time.

In 1609, Hugh Myddelton commenced the formation of the New River, bringing the springs from the chalk at Chadwell and Amwell, near Ware, to within a few miles of London. Funds failing him then, the work was completed by the help of a royal grant, in doing which, by the way, royalty looked well after its own interests, and thus, seven years after the Act had been obtained, the northern parts of London were supplied by a plentiful flow, secured by gravitation. Soon after its completion the water from the chalk springs, which originally formed the only source, were supplemented by an inlet from the Lea.

These two works, together with the natural streams and open conduits, formed the water supply to London till the end of the seventeenth century. But in 1691 a company was formed under the title of the York Building Waterworks Company, to supply the city of Westminster, the water being pumped from the Thames near Charing-cross. These works existed so late as 1829. In 1723 came the Chelsea Waterworks to supply a district of Westminster and the growing neighborhood westward. At first the pumps were erected at Millbank, and afterwards removed to a site near to the present Victoria Railway Bridge. Meanwhile, the narrow arches of old London Bridge were filled with water wheels that clumsily raised water for the city as well as for Southwark. In 1785 the Lambeth Works had started and pumped their supply from the Thames opposite Charing-cross, and the Borough had established pumps not far from Blackfriars Bridge. With the beginning of the century most of the companies which now supply the metropolis came into existence. The West Middlesex Water Company at Hammersmith, in 1806, to supply the western suburbs; the Grand Junction, five years later, who, starting to draw their water from the Colne and Brent, aided by surface drainage, soon had to resort to the Thames for a purer and more constant supply, and in 1820 their sluices drew from the river near to Chelsea Hospital. Eastward the East London Waterworks, dependent for their supply upon the river Lea, superseded two small establishments at Shadwell and Ham; and shortly after their Act had been obtained, in 1806, works were erected near Bow. In the southern districts the Vauxhall Waterworks were started in 1805, taking their supply from the Effra, then an open confluent of the Thames, and but recently converted

into a covered sewer. The various companies thus established, before long, trading on their monopolies, began to levy rates, which resulted in a continued public dissatisfaction, and in 1821 a commission was appointed to examine into the subject. Their report, recommending considerable reform, was never officially acted upon, but it had the effect of inducing the water companies to remove the chief cause of complaint. The quality of water supplied was the next subject that claimed general attention. The various companies drawing their supplies from the river polluted by the sewage discharged into it, distributed it direct throughout their respective districts without any intermediate process of purifying. In 1828 a commission was again appointed to inquire into the quality of the supply. The examinations conducted by this commission showed that the general outcry was a just one, and that the supply, especially from the works below Westminster Bridge, was totally unfitted for general use. Filtering beds, settling reservoirs and removals to new sites followed the publication of this report. The Chelsea Company, in 1829, laid down the first large filter of one acre in extent; the West Middlesex and the Grand Junction removed their source from Chelsea to Brentford; the East London went higher up the Lea, and the Southwark and Vauxhall, combining, established new works at Battersea.

A report by Mr. Telford was made in 1834, in which it was recommended that entirely new sources of supply should be sought, and in which Mr. Telford suggested the Verulam on the northern, and the Wandle on the southern, side of the Metropolis; but this report, although discussed in both houses, remained entirely unacted upon.

The partial improvements introduced by the various companies after 1828 tided matters over for several years, but the development of sanitary engineering resulted in so largely increased a discharge of impurities into the river, that an efficient filtration became impossible, and it was obvious that the time had arrived when some of the most important companies must change their source of supply, or abandon their works altogether.

The Lambeth Company, situated in a most unfavorable position, were the first to take active steps towards the unavoidable change. In 1848 they obtained a new Act, and three years later water drawn from Kingston, far beyond the influence of the tide, was delivered through the mains of these extensive districts.

In 1850, the General Board of Health, who had by that time developed into a most useful and powerful body, issued a report, the minutes of which pointed out strongly the evils existing from the system of deriving a large supply from the tideway of the Thames, and, indeed, they went so far as to assert that the river should only be utilized temporarily for obtaining water beyond the influence of metropolitan drainage, until a more favorable locality could be decided upon, and centralized works erected; and they pointed out the large tract formed by the Bagshot sands, and the lower green sands in Surrey, as suitable for the purpose. This proposition might possibly have been acted upon had not a company at that time been projected for the purpose of supplying London with spring water from the chalk at Watford. The scheme had been so favorably noticed by Robert Stephenson, in a report made ten years before, that it was thought advisable for a commission to investigate chemically the quality of the water obtainable above the tidal influence. The result of their inquiry showed that such water could be thoroughly relied upon for public use, and, condemning the Board of Health proposition relative to turning to the Bagshot sand as a source of supply, they recommended the consideration of the Watford scheme, assuming that the hardness of the water derived from the chalk could be destroyed by Dr. Clark's process for softening.

The termination of all these investigations was a decision that legislation on the subject was necessary, and in 1851 a Bill was introduced into Parliament for the amalgamation and centralization of all the water companies, and the obtaining of all water from one common source. Opposition overcame this measure, but it resulted in an Act being passed the following year, by which stringent and important obligations were imposed upon the various companies, who were left otherwise free to pursue their business independently. The most important clauses of this bill rendered it compulsory that no water should be drawn from the river below Teddington, that all the city storage reservoirs should be covered, that all water, unless pumped from wells should be effectually filtered.

After the passing of this bill, the water companies proceeded to make alterations in compliance with its clauses, which involved an expenditure of 2,500,000 £. and with the result ascertained in 1856, of considerably reducing the amount of organic matter.

Of the eight companies now supplying the metropolis, five are

situated on the north side of the Thames, and three on the southern side. In the long series of articles published in the second volume of *Engineering*, under the title of "The Waterworks of London," the whole of these works were fully described in detail. The following table gives the general statistics of the various establishments in 1867:

	Capital.	Approximate Area of District Supplied.	Number of Houses Supplied, 1867.	Estimated Number of People Supplied, 1867.	Average Daily Supply, 1867.
<i>From the Thames.</i>	£	square miles.			gallons.
Chelsea Company.....	785,600	6.5	26,875	170,000	8,087,258
West Middlesex.....	798,571	10.0	36,881	275,000	8,816,486
Grand Junction.....	850,000	24.0	27,190	245,000	9,533,482
Southwark and Vauxhall.	1,103,440	80.0	71,558	465,000	13,829,758
Lambeth.....	786,245	25.0	38,320	230,000	8,975,530
<i>From the Lea.</i>					49,042,467
New River Company.....	2,609,418	19.0	113,462	810,000	23,790,667
East London Company....	1,400,000	50.0	92,652	675,000	19,298,241
<i>From Chalk Well, Kent.</i>					43,088,908
Kent Company	489,240	60.0	34,504	240,000	6,468,878
Total.....	8,769,514	224.5	441,442	3,100,000	98,600,248

The number of gallons given in the last column of the above table as the amount of daily supply gives only the average, and not the maximum quantity, which in the summer months is augmented to 108,313,000 gallons, showing an excess of 10 per cent. of consumption in the summer over the winter months.

Collectively the various companies possess forty-four subsiding reservoirs, occupying 260½ acres; the filtering beds number forty-eight, with an area of 51½ acres; they own twenty-eight storage reservoirs, having a capacity of 112,087,000 gallons, and ninety-six pumping engines, of 10,660 horse-power in all.

By their present acts and agreements the companies are empowered to draw 110,000,000 of gallons daily from the Thames—the

Chelsea, West Middlesex, Grand Junction, Southwark and Vauxhall, and Lambeth Companies,—each taking 20,000,000 of gallons, and the East London Company (under a recent Act) a quantity equal to 10,000,000 of gallons. From the Lea, the average quantities actually taken are: 18,000,000 of gallons by the New River Company, their total delivery being 23,750,000 gallons; and the East London take 19,250,000 gallons from the Lea, at a point lower down the river. Besides these quantities the chalk wells of the Kent Company yield 7,000,000 of gallons daily.

The commission of 1865, appointed to inquire into the best means of preventing the pollution of rivers, reported that the accumulating sewage discharged into the Thames by all the towns and villages along its course, tended seriously to impurify the river, and that efficient means should be taken to compel the diversion of the discharge, and the utilization of the sewage upon the land. The report resulted in the Act passed in the following year, which legislated for the towns along the Thames Valley, and fixed a limited time for the completion of the dictated improvements, a limit which, by the way, has been exceeded hitherto with impunity. This commission, and also the committee appointed in 1867 to inquire into the condition of the river Lea, were of opinion that with the recommended alterations, both rivers were efficient sources of supply, and that there was nothing to justify incurring a vast expenditure in the formation of new works.

The lengthened discussion which had taken place, and the epidemic which visited London in 1866 (the cause of which, it is alleged, might be traced to the water supply), brought forward many schemes for obtaining a pure supply from a foreign source; of these the principal were Mr. Bateman's project for utilizing the sources of the Severn; Messrs. Heman & Haasard's plan, looking to the Cumberland and Westmoreland Lakes; Mr. Fulton's project for drawing water from the Wye; and Mr. Remington's plan of obtaining it from the Derbyshire hills.

All these different systems, which have been fully described in previous volumes of *Engineering*, were carefully examined into by the recent committee, who concluded that, setting aside all other considerations, there was not sufficient information upon the reliability of the rainfall. It is evident, they say, "that a long series of observations is necessary to be made before any authoritative opinion can be expressed, not only as what may be the true aver-

age rainfall, but what may be the mean of the three driest years, and at what intervals they occur. In the case of a large city like London, where such a source of supply is proposed, an exact determination seems to us imperative. Of course it will be understood that not only should the observations extend over a long series of years, but also that they should be made in many places so as to get at the average rainfall of the district, which has well been shown to have very different values in immediately adjacent places, as it varied in the same year in fourteen areas in the lake district from 45 to 100 inches. The system of collecting grounds utilizes, no doubt, the rainfall to the greater extent. But the great disadvantage is, that the springs to fall back upon in time of drought, are insignificant in comparison with the great quantities stored in permeable strata. The very circumstance of a large immediate delivery of the rainfall precludes the possibility of that subterranean storage of a large portion of it which forms so valuable a resource during severe and long continued droughts."

These objections are substantiated by the experience gained from towns furnished with gravitation—supplies which have in nearly all cases failed in seasons of drought when the requirements were the most urgent. Liverpool, Manchester, Newcastle, Rochdale, Preston, Bradford, Halifax, and other towns supplied by this system, have all suffered from a temporary deficiency or even an absence of water, which involved the hasty extemporising of other means to meet the unexpected demands, or the erection of permanent pumping works to supplement the insufficient ones already existing.—*Engineering*.

THE PRESERVATION OF STONE.

THERE is no name better known in connection with processes for making artificial, or preserving or hardening natural stone, than that of Mr. Frederick Ransome. It is now five and twenty years since, in 1844, Mr. Ransome first turned his attention to this department of scientific research, and during the whole of this time he has been an indefatigable experimenter, discovering obstacles only to surmount them, and never accepting more than a temporary defeat. With the successful results of Mr. Ransome's investigations, as exemplified in his well-known artificial concrete stone, our read-

ers are all no doubt familiar, and we need, therefore, merely allude to them here, the special object of the present notice being to give some particulars of a new process for preserving or hardening natural stone, which has been lately brought out by Mr. Ransome. This process consists in successfully applying to the stone to be treated a solution or fluid mixture of lime or baryta, and a solution of silica, by preference an alkaline silicate.

The solution of baryta which Mr. Ransome prefers to employ consists of half a pound of baryta-hydrate to a gallon of water, and this solution is either applied to the surface of the stone by means of a brush, or, if convenient, the stone to be treated is entirely immersed in it. The stone having been saturated with the baryta solution to the required depth, its surface is next coated with a solution of soluble silicate or a mixture of soluble silicates, such, for instance, as a combination of silicate of soda and silicate of potash. This solution, which Mr. Ransome prefers, should be as nearly neutral as possible, and it may be made so either by adding gelatinous silica freshly precipitated from a weak solution, or by employing the process of dialysis to remove the excess of alkali. For general application it is found most convenient that the solution of soluble silicate should have a specific gravity of about 1.2, but this density may require to be increased or diminished in some cases; for instance, if the material to be treated is very porous, or if it is merely desired that the hardening should be effected to a slight depth only, a stronger solution may be used, and the same remark also applies to the solution of baryta. In some instances, also, Mr. Ransome proposes to employ a solution of lime in place of that of baryta, and, if necessary, molasses or sugar may be added to increase the quantity of lime held in solution.

Mr. Ransome has also brought out a modification of the above described process, in which the application of the solution of baryta, to the stone is preceded by the coating of the surface of the latter with a solution of superphosphate of lime of a specific gravity of about 1.06; or, if desired, the baryta solution may be applied first and the superphosphate subsequently. Mr. Ransome has, we understand, lately applied his new preserving process to the stones of the St. Pancras Station, and we hope in a future number to say more of its use and the results attending it.—*Engineering.*

OPENING OF KANSAS CITY BRIDGE.

Engineer's Test and Report.

THE Kansas City Bridge was formally opened July 3d, with appropriate ceremonies; the municipal authorities of Chicago and St. Louis, and an immense concourse of people participating.

The bridge consists of combination wood and iron trusses for spans 130 feet, 177 feet, 200 feet, and 250 feet, an iron span 70 feet, and a Linville & Piper patent wrought iron pivot span 360 feet in length. The superstructure was erected by the Keystone Bridge Company, of Pittsburgh.

The tests were made by careful instrumental measurements, the bridge being loaded with a train of five locomotives and cars loaded with railroad iron. The committee remark that they must meet the approval of all practical and scientific men, acquainted with the difficult problem of bridging with long spans such streams as the Missouri:—

Span 7. Length of Span 177 feet. Load at North. $\frac{1}{4}$ of span, 46 Tons.

North $\frac{1}{4}$ deflection 14-32 inches.

Centre " 10-32 "

Load at Centre and North $\frac{1}{4}$, 92 Tons.

North $\frac{1}{4}$ deflection 24-32 "

Centre " 31-32 "

South $\frac{1}{4}$ " 28-32 "

Load at South $\frac{1}{4}$, Centre and North $\frac{1}{4}$, 112 Tons.

North $\frac{1}{4}$ deflection 26-32 "

Centre " 34-32 "

South $\frac{1}{4}$ " 38-32 "

Span fully loaded, 170 Tons.

North $\frac{1}{4}$ deflection 27-32 "

Centre " 37-32 "

South $\frac{1}{4}$, " 38-32 "

Elongation of bottom chord under full load $\frac{1}{4}$ inch, set after load passed off 1-16 of an inch.

Span 6. Length 200. Loaded with four Engines. Total weight 187 Tons.

North $\frac{1}{4}$ deflection 42-32 inches.

Centre " 54-32 "

South $\frac{1}{4}$ " 41-32 "

Elongation of bottom chord 11-32 "

Set 13-32 "

Span 5. Length 250 feet, fully loaded 233 Tons.

North $\frac{1}{4}$ deflection 51-32 "

Centre " 69-32 "

South $\frac{1}{4}$ " 48-32 "

Elongation of bottom chord 8-8 "

Set 5-32 "

Span 4. Length, 200 feet. Loaded, 187 Tons.

Centre deflection 110-32 "

Set nil

Draw Span 360 feet. North half of draw span loaded with 170 Tons.	
North $\frac{1}{2}$ deflection.....	23-32 inches.
North Centre ".....	34-32 "
$\frac{1}{2}$ adjoining drum deflection.....	15-32 "
Centre of South half, unloaded, rose under above load....	19-32 "
Draw Span fully loaded, 318 Tons. On South half of span.	
South $\frac{1}{2}$ deflection.....	9-32 inches.
Centre ".....	18-32 "
$\frac{1}{2}$ adjoining drum.....	15-32 "
North half of Span.	
Centre deflection.....	19-32 "
Set in South $\frac{1}{2}$ Truss.....	3-8 "
Set in North $\frac{1}{2}$ Truss.....	1-8 "
Time of opening draw 72° two minutes and ten seconds with four men. Elongation of Span, 2,180 feet in length under the moving load of five engines and loaded train was 7-32.	

J. B. Moulton, late Chief Engineer North Missouri Railroad.

Walter McFarland, Major of Engineers, U. S. Army.

Geo. H. Nettleton, Chief Engineer, Hannibal and St. Joseph Railroad.

John B. Lodge, Engineer North Missouri Railroad.

Joseph S. Smith, Keokuk and Hamilton Bridge.

J. K. Thompson, Superintendent Bridges and Streets, Chicago.

A. Anderson, General Superintendent, Kansas Pacific Railroad.

D. J. Morrell, Superintendent Cambria Iron Works.

H. C. Moore, General Superintendent and Chief Engineer, Missouri Pacific Railroad.

The committee say:—

"The results were entirely satisfactory, reflecting great credit on all concerned in its construction, especially on the Chief Engineer, Mr. O. Chanute, who has shown the greatest scientific skill and administrative ability in its design and superintendence, and in successfully accomplishing the building of this, the first bridge across the Missouri River; the masonry of its piers having to be sunk from 40 to 50 feet below the bottom of the river, through quicksands and driftwood, in a turbulent part of the stream."

The opinion is expressed that the engineering profession will be greatly benefited if Mr. Chanute will publish a detailed statement of the building of this bridge, and the committee respectfully request him to do so at an early period.

KANSAS CITY BRIDGE.

FROM the *Missouri Republican* of St. Louis, we extract the following details of the structure and erection of the Kansas City Bridge, whose opening and Engineer's Test will be found fully described on another page.

Preliminary arrangements of charter and finance having been made, the services of Mr. O. Chanute as Chief Engineer were secured.

Mr. Chanute associated with him as assistant engineers Mr. C. H. Nickerbocker and Mr. G. S. Morison, and no time was lost in delay. He surveyed the river and the proposed location for the bridge and the customary routine of boring to find the rock was gone through in January, 1867. In February he gave up his residence at Chicago and came to Kansas City to superintend and conduct the operations. The location of the bridge was determined upon, and a point about opposite the centre of the town chosen. The works were commenced vigorously, and it soon became evident that the greatness of the task had not been at all over-estimated. A survey of the bed of the channel had been made, and the fixity of the latter being suspected, another one was made a short time afterwards. The second showed that it had sunk several feet. Again and again were surveys made; the bed would rise and fall, and where large deposits of sand had recently taken place, a huge depression would be noticed not long after. What, with the scouring and filling up, and the eating away of the bank and the continual shifting of portions of the bed, the engineer was driven almost to his wit's end. Still the river was there and it had to be bridged. Although the channel became twenty feet deeper in two months, and the obstacles were enough to dismay any ordinary man, Mr. Chanute attacked them with a bolder heart.

The eating-away process of the voracious monster went on quicker than had been counted upon, and actually 500 feet of the bank some distance above the site of the bridge was swallowed up and went down stream in five days. This would never do and it was decided to have recourse to riveting. Two miles of the southern bank were protected in this manner, the whole distance from the bridge site to the mouth of the Kansas River being riveted.

The history of the first year's operations was simply this, a struggle from beginning to end with the river and its ever-changing bed.

Temporary works—piles driven into the sand were undermined and swept away, and at one time Kansas City was threatened with a sand bar, which would leave it isolated, so far as river navigation was concerned. "Necessity is the mother of invention," and Mr. Chanute did discover a method by which the majesty of science was asserted over an unchecked and uncontrollable body of water.

The current being very swift and powerful, it was found impossible to build the foundations of the bridge in the ordinary manner, and an ingenious plan of protection was devised. A bottomless caisson was lowered by means of screws which were fastened to a timber frame, itself secured to the rock by drills. Another caisson was secured by cables a little distance up stream to break the force of the current. After the caisson had been lowered it was made water-tight, and the work proceeded. This plan was specially adopted for pier No. 1. With the other piers sheet piling, false works, dredges and syphons, and the making of caissons water-tight by bags of concrete placed around them by drivers, were had recourse to. The caisson for pier No. 2 was peculiar, being like a round barrel some forty feet in diameter. Many of the piles were sunk by the aid of a water jet.

The foundation of pier No. 4, writes an engineer connected with the works, presented the greatest difficulties, and as finally carried out was the most successful. The caisson built and partially sunk in the fall of 1867 remained in position until the following March, when the river in two days scoured away twenty feet of sand on the side next to the channel, causing the caisson to tilt rapidly toward the south, till it fell over, and became a total wreck. It was then necessary to begin this foundation anew, and for greater security it was decided to dispense with piles and found the pier directly upon the rock. As the work must be done in the low-water season of fall and winter, when the deposit of silt and sand is the greatest, it became necessary to go through nearly forty feet of deposit, twice as much as at any other pier, to a depth fifty feet below the ordinary stage of water. To accomplish this, the bold and novel plan was adopted of substituting a masonry pier for the bottomless caissons used elsewhere, and sinking this pier bodily to the rock, building up as it descended; the pier being guided in its descent by suspension screws, and the material removed from below by endless chain dredges working in wells left in the masonry. To avoid the delay which the obstructions of the old wreck would have

entailed, the site of the pier was shifted fifty feet to the south, putting the two hundred and fifty feet span between piers four and five. A timber caisson seventy feet long, twenty-two and a half wide and twelve feet high, with pointed ends, was built on the shore to carry the masonry. It was built with double walls, the outer vertical, and the inner inclining inward and upward, the two uniting at the base in a sharp, cutting edge, shod with iron, and made with three cross-walls of similar form. This caisson was proportioned to carry the entire weight of the pier, and to resist all pressures and disturbances which might come upon it. Some idea of its strength may be derived from the fact that 60,000 feet of lumber, mostly oak, and 22,000 pounds of wrought iron were used in its construction. While the caisson was building on shore, the false works were in progress at the pier site; they rested on sixty piers, which were surmounted by seven trusses capable of carrying a thousand tons, or, if absolutely necessary, double that weight. Twenty-four suspension screws, twenty feet long, and from two and a half to three inches in diameter, were placed in the truss-frame above, and twenty-four two and a half inch rods, in corresponding positions, were built into the caisson, passing through the timber sides from top to bottom, and taking hold below the main sill. On the 21st of October, the caisson was launched and floated into position. It was then suspended from the trusses, the false bottom removed, and the caisson lowered till it rested on the sand in nine feet of water. After filling the spaces between the double walls with concrete, the outer wall was surmounted by a planked frame wall twelve feet high, built with a slight batter, and the spaces left between the inner and cross-walls, by four rectangular boxes, which formed the walls of the dredge wells. This second section was also filled with concrete. At the same time the dredging machinery was mounted above, and a house built over the entire work, to protect the workmen and machinery from the weather and facilitate the prosecution of the work both night and day. The false works were arranged in three separate stories. The lower floor, only a few feet above water, was reserved for the use of the carpenters and masons engaged in building the successive sections of the caisson and laying the masonry. This floor contained also the engine-room and divers' houses, with air-pumps and apparatus, while an extension built out on the north side furnished runways to carry off the sand thrown out by the dredges. The second floor, entirely housed in, contained the shaft-

ing and connections by which the dredges were run—each dredge being inclosed by itself to confine the splash of sand and water—the machinists' work-benches, superintendent's office, lamp room, etc. On the third floor, immediately under the roof, were placed the crabs used in raising and lowering the dredges. The dredges were of the endless chain pattern, arranged specially for this work, with vertical telescopic frames, by which the working length was increased as the pier descended, the frames being also easily moved up and down, independently of any change in length, by the crabs.

On the 28th of December, everything being in readiness, the machinery was set in motion and the sinking began. The dredges were easily driven by a single twenty-five horse-power engine, and little difficulty was found in securing a uniform descent by the aid of the suspension screws. The material first excavated was a fine, sticky silt, which could be dredged only when mixed with a large quantity of water, forming a thin mud; the rate of descent was, however, materially faster than either concrete or masonry could be laid. The second section of the caisson was in turn surmounted by a third, within which the cut-stone masonry of the pier was laid, the planking serving as a protection from the sand. It was found best not to sink both night and day as the splash from the dredges greatly inconvenienced the masons, and the plan was adopted of working the dredges by night and laying masonry in the daytime. As the pier descended the character of the material excavated changed to a coarse heavy sand, easily dredged, and the progress became more rapid, six inches being sometimes accomplished in a single hour, while it was easy to go down in six hours as far as the masonry could be built up in eighteen.

A delay of a few days was occasioned by striking on two sunken piles, which probably belonged to the old wreck; one of these was removed by the divers, and the other tied up and held till the edge of the caisson broke through it; the timber was ten inches thick where it broke, and showed a ragged broom-like fracture. On the 6th of February, the masonry having been stopped a day or two before, the pier came to a bearing on a mass of clay and boulder, through which it was worked slowly about a foot in the usual way. A force of eight divers was then engaged to finish the excavation; they worked in alternate gangs day and night in the chambers of the lower section beneath the masonry, removing the boulders one by one. The stones were of various sizes, from small pebbles to

two hundred and fifty pounds weight, closely packed together, and showing no signs of wear by water; among them were found occasional masses of clay, pieces of water-charred wood, a number of teeth, and an Indian arrow-head. By the 10th of March the divers had worked through four feet of these boulders, and brought the pier to a bearing on the bed-rock. The small amount of sand which remained inside was then cleared out, the dredge removed, and the wells filled up with concrete; the false works were stripped to the lower platform, a derrick mounted, and on the 2d of April the laying of masonry was resumed, the last foundation being finished. On the completion of No. 2, the force on this pier was doubled, and the last stone in the bridge laid on the 5th of May, 1869.

Most of the difficulties incidental to the construction of the bridge have been mentioned in the foregoing, and we will now notice the structure as completed.

The general impression created on first viewing the bridge from a distance is a very favorable one, and which is strengthened on approaching nearer to it. It presents a substantial appearance, although the superstructure is light. The distance from the water to the roadway of it at the present stage of the water is 32 feet, at low water 47 feet, and at high 11 feet.

From the abutment on the Kansas City shore to the two pillars at this end of the bridge the distance is 66 feet. The abutment is a massive one, and the pillars are 7 feet square at the base, and also 7 feet at the top, while they are 5 feet through the neck.

The piers have a curved cornice, and are formed like an Egyptian pillar. The "ice-breaker" at their bottom tapers toward the top, and has a sharp point. There are, in all, seven piers.

Pier No. 1.—The distance from the pillars to the first one is 134 feet. It rests on a rock, is 100 feet from the shore, 63 feet in height, 65 feet by 20 at base, and 40 feet by 10 feet at the cornice; 8 feet through the neck. The distance from it to pier No. 2 is $181\frac{1}{2}$ feet.

Pier No. 2.—This is the round pier on which the draw swings. It is 40 feet at the base, 29 feet through the neck, and 33 feet at the cornice. It rests on a rock, and is 66 feet high. Distance to pier No. 3, $181\frac{1}{2}$ feet.

Pier No. 3.—This is distant from pier No. 4, 200 feet; is 79 feet in height, 70 feet by 21 feet at base, 40 feet by 10 feet at the top, and is 8 feet thick at the neck. It rests on rock.

Pier No. 4.—The span to pier No. 4 is 250 feet; height of pier, 90 feet; 70½ feet by 22½ feet at the base; 38 feet by 9 feet at the top; 7 feet at the neck. It rests directly on a rock.

Pier No. 5.—The span between this pier and pier No. 6 is 200 feet. Dimensions: At base, 70 feet by 15 feet; at top, 38 feet by 9 feet; neck, 7 feet; height 56 feet. Rests upon piles driven to the rock.

Pier No. 6.—Span to pier No. 7, 177 feet. Size of pier: 60 feet by 13½ feet at bottom; 38 feet by 9 feet at top; neck 7 feet; height 75 feet. Rests upon piles driven in the sand.

Pier No. 7.—The dimensions of this pier are: At bottom, 40 feet by 11½ feet; 36 feet in length at top; 45 feet high; 6 feet through the neck. It rests upon 75 piles driven into the sand, which is 10 feet below low water.

The masonry of the piers is of limestone, quarried in the neighborhood; the facing is of ashlar, and the backing of heavy rubble.

The Superstructure.—The superstructure is composed of iron and wood. The contract for it was taken by the Keystone Bridge Company, of Pittsburgh. The short shore span is a riveted trellis girder of wrought iron. The other fixed spans are double triangular trusses, of a pattern designed for this bridge; the lower chord, and all parts strained in tension, are of wrought iron, the top chord and braces of wood; the three longest spans have curved upper chords. The construction of the bridge is such that any portion of the superstructure can be replaced, in a few moments, without interfering with the passage of trains. This does not decrease its stability.

The superstructure rests upon cast iron bed-plates on rollers in an iron case, to allow for the contraction and expansion of the iron work, caused by the changes in temperature. The roadway is laid with Nicolson pavement, and the rail is what is known as a strong steel rail. It was rolled especially for this purpose, is much heavier than they usually are, weighing sixty-eight pounds to the lineal yard. It is adapted both for steam cars and ordinary carriages. The bridge has been constructed with a view to the allowing of buggies and wagons to pass over it when not in use by the railroads. There is a footpath along the side for its entire length. After the celebration a toll will be charged, probably 4 or 5 cents for a single person, and about 50 cents for a buggy. The roadway is 18 feet wide, and the footpath 4 feet.

The Draw.—Perhaps the most interesting portion of the structure is the draw. It is 363 feet in length from the centre of pier No. 1 to the centre of pier No. 3, and is entirely of wrought iron. It is of Linville & Piper's patent. The "draw protection" in the river is the same length as the draw, and "rests" are placed on cribs which were sunk filled with stone. When the draw is swung round to permit a steamboat to pass, its ends will rest on these. The draw is easily worked by four men, with wrenches; it is intended to place a small steam engine on pier No. 2, to work it. The draw works very nicely.

The gauge of the track on the bridge is the narrow gauge of 4 feet 8½ inches. The track of the Missouri Pacific Railroad is now 5 feet 6 inches, and it is understood that it will be altered to the narrow one, which is used by all the other railroads connecting at this point. The track on the bridge is a single one.

The distances from the track of the bridge to the centre of the spans are respectively 22 feet, draw 35 feet, 25 feet, 31 feet, 25 feet, and 22 feet.

A telegraph wire of the Western Union Telegraph Company is carried over by the bridge.

The bridge is estimated to carry one ton to the foot. At this weight the wrought iron is only strained up to 10,000 pounds the square inch, and the timber to 400 pounds. This is twice as much as it is ever likely to carry. On the test, to-day, it will be subjected to the weight of seven locomotives, extending from end to end. It is estimated that it will carry four or five times this weight, and ten times the actual weight ever likely to come upon it in service.

The deflection, when the greatest weight that can be put upon it is done, will be 1½ inch for the 188 feet span, 1½ inch for the 200 feet span, and 1½ inch for the 250 feet span.

The bridge has been partly tested already, and trains have passed over it, with two locomotives and two cars loaded with iron, weighing 100 tons. The deflection of the 250 feet span is 1½ inch.

Other Work.—Beyond the northern end of the bridge there is 2,363 feet of trestle work, 30 feet in height; this is over the bottom lands to the high grounds. On the opposite shore there has been a deep cutting, 1,400 feet in length and 73 feet deep in the middle. Further on there has been rock cutting 1,000 feet in length by 40 feet in height. The railroads on the south side make their connec-

tions with the track at the end of these cuttings, and those on the northern side of the Missouri at the end of the trestle work.

Quite a picturesque view of the surrounding country is obtained by a person standing in the centre of the bridge. There is a sudden bend in the river here, and looking west up the river, the pretty little town of Wyandotte, Kansas, is seen straight ahead, on the south or west bank of the river. A short distance below, the State line is distinguished by a belt of timber on the Kansas border. On the northern side of the river, a little below the bridge, there is Harlem, the terminus of three railroads, destined to receive some of the benefits that will flow from this enterprise. The high bluffs of Kansas City are on the southern side, and a cute, wide-awake person who owns a lot near the terminus of the bridge can be seen washing the bluff away with a stream of water forced up from the river, in hose, by a stationary steam engine. A laborer directs the nozzle at the base of the bluff. The hill melts and flows in a thick muddy stream down a trench, again to mingle with the turbid waters below, after having been solidified for centuries. The owner of the dirt is progressing with the demolition. This, however, is a digression. Opposite Kansas City there is nothing but a few shanties in the primitive forest, and it is rumored that they are to form the nucleus for a "New Kansas City." Lots have risen from \$100 to \$1,000 per foot.

A large number of trees and branches are coming down the Missouri, and quite an accumulation has taken place at the western end of the "draw protection" and some of the piers. They will only, like masses of ice, beat harmlessly against them.

The railroads which will be enabled to connect at Kansas City, by means of this enterprise, are the Kansas City and Cameron Railroad; North Missouri Railroad; Missouri Valley Railroad; Missouri River, Fort Scott and Gulf Railroad; Missouri Pacific Railroad; Missouri River Railroad, and Kansas Pacific Railroad.

The connections will be equally beneficial to all these roads, and, if to any specially, to the St. Louis roads. The roads which ran on the northeast side of the river were the North Missouri; the Missouri Valley Railroad running to St. Joseph; and the Kansas City and Cameron Railroad. The Missouri River Railroad is the road which is operated in connection with the Missouri Pacific, and runs to Leavenworth. The Missouri River, Fort Scott and Gulf Rail-

road has 55 miles constructed, south, and is being pushed to the Indian Territory.

The total cost of the bridge has been about \$1,000,000. It may slightly exceed this, but very little. The contract for the superstructure was \$250,000, and this is included in the sum. In this \$1,000,000 there is also included the cost of 2,368 feet of trestle work, the 1,400 feet of cutting, and the 1,000 feet of rock cutting before referred to.

No account of this bridge would be complete without a word respecting Mr. O. Chanute, the Chief Engineer. He has won deserved fame in his profession, and has cause to be proud of this last signal achievement. He is an affable and courteous gentleman, and has been ably assisted by Mr. C. H. Nickerbocker, G. S. Morison, and Mr. T. Tomlinson, the latter of whom had charge of the iron work.

Local Attraction.—Colonel Sir Henry James, Director-General of the Ordnance Survey, reports that during the past year inquiry has been prosecuted into this very remarkable phenomenon. He observes that the relative extent to which the plumb line, and the levels of our astronomical instruments, are affected in a country where there is nothing on the surface of the ground to account for it, may be judged from the fact that it is nearly double the amount of the deflection on Schehallion mountain, 3,547 feet high, with the instrument placed on the sides of the mountain itself, at one-third of its altitude, the position to produce the greatest effect from the mass of the mountain on the plumb lines. He considers that we have very decided indications that the cause is in the granitic rocks which extend in a south-west direction from Cowhythe through Banffshire, and which are highly impregnated in some parts with magnetic iron in a metallic state. The range of mountains on the south-east of Banffshire culminates in Ben Muich Dhui, 4,305 feet high, which, after Ben Nevis, 4,368 feet high, is the highest mountain in Scotland. The great amount of the attraction at Cowhythe, and along the coast to the east and west of Portsoy, cannot be explained by anything visible on the surface, and obliges us to imagine the existence of some large and very dense mass of matter underneath it. Sir H. James hopes to resume this important inquiry this season; and the geological structure, as well as the mineral character of the rocks, will be carefully investigated by the Director of the Geological Survey of Scotland.

Mechanics, Physics, and Chemistry.

ON VARIOUS PROCESSES FOR PRESERVING TIMBER.

BY DR. ADOLPH OTT.

"Le probleme de la conservation des bois est une question qu'on peut mettre au premier rang parmi les questions les plus importantes d'economie publique." *Dumas.*

Early Trials. The effects of Metallic Salts. Experiments made on German Railroads.

"WOOD is an outgrowth of the earth, by which nature provides for the payment of our debts," was the utterance of Lord Carnarvon, during the then raging gambling mania under Charles II. of England. Many a venerable old forest had to fall, in order to cover the losses at the play-table of but one evening. Is it to be wondered at, that from this time dates the first attempt for protecting timber from rot? It originated with the German chemist Glauber, and consisted in first charring the surface of the timber, then coating it with vegetable tar, and immersing it in the acid from wood. From the past century date also various methods for preserving timber. They are founded either on the application of tarry, oily or resinous substances to the surface of the wood, or on its immersion in various fluids. These processes are likewise found to be alternately applied. The present century, as may be expected, has brought forward a great number of inventions with regard to this subject. The usual methods consist in drying the timber by hot air; in lixiviating it by cold water, steam, or chemicals; in its immersion in various liquids; or, in impregnating the same with fluids by means of pressure, after expelling the sap. Boucherie's process, which is the only original one of its kind we are acquainted with, consists in displacing the sap of the living, or felled and squared tree, with saline solutions.*

* The first patent of Dr. Boucherie dates from the year 1838. It is founded on the ascending force of the sap, which causes the preserving fluid to pass through the stem upwards to the ramifications. The latter is brought in contact with the juice through a circular saw-cut at the base of the standing or with the entire surface of the cut of the sawed down tree. The "*green log cured in the forest*" became at that time the object of great wonder. In 1841, Boucherie proposed another method by which the expelling and displacing of the juice is effected by

The preserving fluids now chiefly employed are metallic and saline solutions, and the products of the destructive distillation of coal and wood. Most metallic salts, as well known, form scarcely soluble, and not readily putrefiable, compounds with albuminous matter; these latter form, to a large proportion, the contents of the vegetable organs, and, being exceedingly liable to spontaneous decomposition, constitute, in most instances, the decay of the ligneous tissue, or of the fibro-vascular bundles around the pith, of which wood, properly speaking, is composed. In effecting, therefore, such combinations in the interior of the wood, it was supposed that they would be the means of effectually arresting this transformation. In doing so, it was, however, not taken into account that those compounds are themselves easily soluble in a surplus of the metallic solution, or in the albuminous juice itself.*

By the usual methods of injection, a thorough saturation of the wood is but rarely effected, and although it may be taken for granted that as long as the preservative fluid remains in the interior of the cellular tissue, no decomposition will ensue, this will most assuredly be the case when the fluid in question has been removed by the action of either terrestrial or meteoric waters. Aside from this, the investigations of a very careful observer, Mr. Koenig, seem to prove that the metallic salts unite more readily with the resins than with the albumen of the wood. His researches extended over various kinds of timber which had been impregnated with copper and zinc solutions. He ascribes the temporary preservation of timber to the formation of a "resin soap," as he terms that compound, which, in covering the fibre, affords some protection against the growth of fungi or the attacks of insects. It was found that non-resinous wood absorbs very little of these metallic salts, and sulphate of copper, when injected in wood from which the resin had been removed by boiling it in alcohol, could easily be lixiviated by laying the thus saturated wood in water. Steamed oak absorbed more chloride of zinc than green or seasoned oak, a fact which may be accounted for when it is known that in steaming, the pores are widened while

pressure. The preserving fluids chiefly employed by him are sulphate of copper, pyroligneate of iron, and chloride of calcium. This process has since been adopted by several railroads, and for impregnating the telegraph posts in France. Four years ago, a certain Mr. Hamar obtained from the United States a patent for a similar process, the alleged merits of which we shall examine presently.

* Vide *Lehrbuch der organischen Chemie* von T. E. Schlossberger. Leipzig and Heidelberg. 1867; page 144.

the resin remains.* These facts fully explain, as reported in one of the annual meetings of the German Civil Engineers, why not less than 46·59 per cent. of the pine sleepers of the Kreuz-Bromberger Railroad, which had been treated with blue copperas, had to be removed after only ten years' service.†

Injection with Brine. Salting Timber.

With regard to the injection with brine after the method of Boucherie, it may be stated that it failed like many others, to give the satisfaction required. That the external application of salt, as practised for increasing the durability of timber in vessels, must be still less satisfactory, is self evident.

In an excellent article on the ship-timber in the United States, prepared expressly by Mr. William W. Bates, of Chicago, Illinois, for the Commissioner of Agriculture, the author speaks‡ as follows, on the alleged utility of salting:—

“There can be no doubt of the utility of salting close assemblages of timber, provided the pieces are not too large; but if large, not too green. The action of salt upon timber seems to be imperfectly understood. It is seldom applied to advantage, as may be seen from the mode of using it, namely, against the dry sides of the timbers instead of the moistened ends, which is rather impracticable. It results that water from the wood is very slowly obtained, which is shown from the length of time it takes to dissolve the salt—several years. During this time, incrustations are formed over the surface of the wood; these are cooled and preserved, *but the interior of the timber, especially if large, not having parted with its moisture and fermentable juices, may be decomposed, as we have seen, despite the salt.* From this we are led to infer that a proper application, either in mode or quantity, would have saved the interior as well as the outside of the timber. But this is by no means certain, however. *Salt, in its nature, it is not constituted to perform all the functions of a perfect antiseptic for timber, and, besides, is too slow in its action.* If the timbers of a ship could be made small enough

* Aus der Natur. Die neuesten Entdeckungen auf dem gebiete der Naturwissenschaften. 1863; page 598.

† Chemisch technisches Repertorium von Dr. Emil Jacobsen. 1864; 2d half year, page 8.

‡ Report of the Commission of Agriculture, for the year 1866 Washington, 1867.

in scantling, salt might answer to save them; but salt would scarcely save an ox were the carcass not cut up, and it is equally useless applied to timber. It is also a most weighty and cumbersome material, and would be more so, if applied to the extent required."

[The italics are by the author of this article.]

The Process of S. Beer.

Quite recently attention has been called to a process for preserving timber, invented by S. Beer, in New York. The same consists in the treatment of the wood in a boiling solution of borax in water, and came to our notice through a German periodical of last year.* It is claimed therein that all the putrefiable substances are effectually removed by the borax; moreover, it is held that the ligneous fascicles become harder and less absorbent, that the treatment protects the wood from insects, keeps it dry and inflammable. The process itself is carried out in the following manner: In a vessel of wood or iron a saturated solution of borax in water is prepared, the quantity of which must be sufficient to cover the timber. The temperature of the solution is then raised to the boiling point, either by introducing steam or otherwise. This is kept up for two to twelve hours, according to the porosity and density of the timber, when the operation is repeated with a new and concentrated solution. At this time, the wood is only kept for half the period in the liquid. It is now withdrawn, and when dry, is ready for use should its hardness and color not present objections.

Let us now examine this process a little closer. The fact that borax is soluble in about twelve parts of its weight of cold water, makes this process inapplicable for structures which are to be exposed to terrestrial or meteoric waters, for the reason that the intended protective coating will be slowly removed. Again, borax being of a hygroscopic nature, if not refined with the utmost care, will soon absorb water, and thus leave the wood in a damp, instead of a dry state. Naturalists in selecting borax crystals for their collections, well know that they have to coat them with a varnish, or otherwise they would soon become white and opaque, on account of their affinity for water. But a still more serious objection against this process consists in the property of alkaline fluids, such as a solution of borax; of dissolving or at least attacking certain sub-

* The Gewerbeblatt feor das Grossherzogthum Hessen. No. 22; 1868.

stances of the wood upon which its strength, solidity and toughness, and other desired properties greatly depend. Those substances are the so-called incrusting materials. They form in concentric layers the inner walls of the ligneous cells, they being abundant in the hard woods, and the stones of fruits, when they often fill the entire space of the cell. In the making of paper from wood, all that is wanted is the supple, pliant cell. The manufacturers' attention is therefore directed to the removal of the non-fibrous bodies, which end he accomplishes by the boiling of the previously reduced wood in alkaline lyes, but the paper obtained, though smooth and elastic, and capable of taking the highest finish, lacks that degree of firmness necessary to make it a fitting material for better kinds of paper. In the course of this article, I shall have occasion to dwell fully on the importance of the natural resin contained in timber in its bearing on the durability of wood. It is certainly not an advantageous feature of the above described process, that the resin is altogether removed by it; and in regard to its claimed superiority in withdrawing the putrefiable substances, it may be stated on good authority (experiments conducted at the College of the City of New York), that not less than 14 per cent. of the original amount of albumen have been retained in sawdust after boiling the same several times, and each time for hours, with a saturated solution of borax.

Coal Tar, and its products, as preservatives of Wood. The experiments of Professor Rottier.

The products of the destructive distillation of carboniferous bodies belonging to the coal series have often been recommended for the purpose in question. Some have preferred the light, others the heavy oils, some force the preservative in the wood while in its liquid state, others endeavor to accomplish the same end by exposing the timber to its vapors.

It is not my intention to enter into the history of the various trials and their results; with regard to these, I refer to an ably written article in the *Scientific American*, June 12, 1869, entitled "Coal Tar, and its products as preservatives for Wood." My purpose is simply to relate some experiments which were undertaken by *Mr. Rottier*, Professor of Chemistry at the University of Ghent, Belgium, in order to determine what ingredients of the coal tar are most effectual in protecting wood from rot. An account of these

experiments may be found in the *Breslauer Gewerbeblatt* of 1865 (page 152). Rottier's experiments extend over the following constituents of coal tar:—

1. The light oil.
2. The oil containing carbolic or phenylic acid.
3. The oil containing aniline.
4. The naphthalized oils.
5. The solid resoden.
6. The green, fluorescent oil distilling between 275 and 320 centigrade, containing pyren and paranaphthalin.

(To be continued.)

ON THE COMPUTING AND COMPARING OF INDICATOR DIAGRAMS.

Read before the Polytechnic Society of the American Institute, April 29th, 1869.

By G. H. BABCOCK.

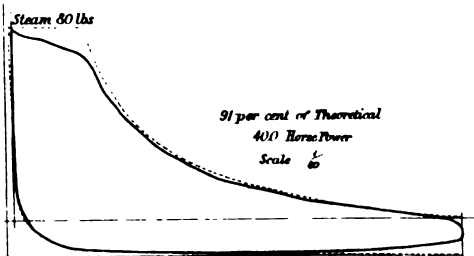
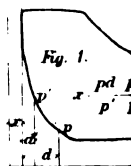
It is a fact well known to engineers, that by none of the ordinary methods of expressing the comparative merits of different engines, can a satisfactory conclusion be reached as to the value of any peculiar construction, unless all the conditions and circumstances under which the comparison is made are precisely similar. The amount of coal burnt per hour per horse-power is a common criterion, but so many other conditions than that of the construction of the engines enter into and affect the result, such as the evaporative efficiency of the boiler, the quality of the fuel, the load, the amount of protection to the boilers and pipes, from radiation, etc., that it affords no just criterion by which to judge the perfection of the engine alone, unless these several conditions are all equal in the classes in which a comparison is desired.

The amount of water required per hour per horse-power gives a much nearer approximation to the relative value of different engines; but in this comparison, also, it is necessary that the load relative to the capacity of the engine, the quality of the steam, whether dry or wet, and all the exterior conditions should be precisely similar, to render the comparison just. But even when the exterior conditions are similar, neither of these tests give any result by which can be determined, save by inference, the relative advantages of different mechanical arrangements or proportion of parts. It being almost impossible, except by special construction for the purpose of experiment, to find two engines under circumstances where the sole difference is in some specific point of arrangement or proportion, the precise effect of that difference cannot be determined by the consumption of fuel or water.

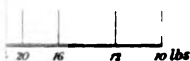
The use of the indicator is the most satisfactory way yet devised for ascertaining the relative efficiency of various constructions and styles of engines, under differing conditions; the shape of the diagrams produced by this instrument giving to a practiced eye—but only to such—an indication of the relative perfection of the valve-motion, the size of the passages, and the general efficiency of the machine. But it is desirable to be able to compute these diagrams in some way which will give a mathematical expression of their several grades of efficiency, and thus enable us to express the comparative values of different forms of construction, independent of the varying conditions under which the diagrams have been taken, and a method of accomplishing this object forms the subject of the present investigation.

It is evident that an engine which has no losses from clearance, condensation or leakage, which takes the steam at boiler pressure until the point of cut-off, expanding in accordance with the hyperbolic formula, exhausting at the end of the stroke to atmospheric pressure, or to perfect vacuum, according as it is condensing or non-condensing, performing the back stroke with no back pressure (back pressure being reckoned from atmosphere if non-condensing or vacuum if condensing), and compressing if at all, on the hyperbolic curve, would give the utmost power which could be obtained practically from that amount of steam used under that pressure and degree of expansion. And it being self evident that the engine which approaches nearest in its action to the above has the best proportions and arrangement of its mechanism, we will adopt it as a standard and proceed to institute a comparison of the diagram made by a given engine, with this standard engine having the *same capacity* (including clearance) *and using the same amount of steam with the same boiler pressure*; that is, we propose to compare each diagram with a diagram calculated for a theoretically perfect engine under precisely similar circumstances.

The amount of steam expended in producing the power developed in any particular case, is measurable in two ways: by the amount which enters the cylinder, and by the amount which is discharged therefrom. Had we the exact means of measuring either of these quantities, we should, of course, find them precisely equal; but owing to the unavoidable condensation within the cylinder, part of which is reëvaporated during expansion, and of more or less leakage into the cylinder after the valves are closed, the indicator diagram nearly always shows an apparently greater quantity of steam exhausted than received. The exact point of cut-off or suppression is, in most cases, also very difficult of determination by means of the diagram, while it is not difficult to decide upon the point of exhaust, with sufficient accuracy for our present purpose; consequently a nearer approximation to the true amount of steam used may be obtained by measuring the steam exhausted than by the induction.

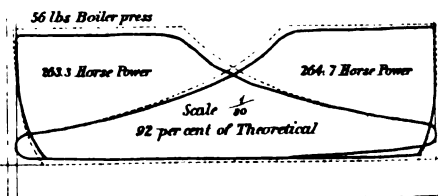


Babcock & Wilcox Engine DRUID MILL.
Cyl. 28^{ins} Dia 72^{ins} Stroke 46 8 Revol

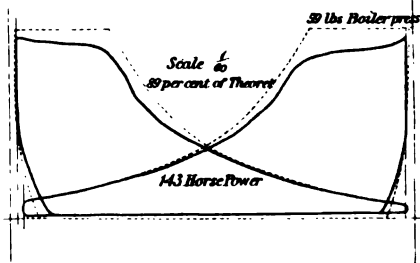


arious Scales.

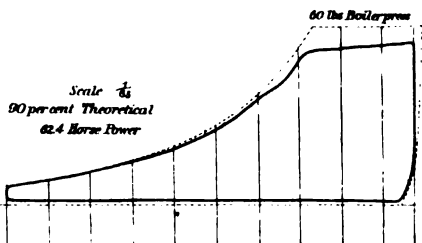
Fig 5.



Babcock & Wilcox Engine ATLANTIC MILL.
Dia. of Cyl. 26 ins. Stroke 4 feet. 60 revol.



Babcock & Wilcox Engine KINGS COUNTY FLOUR MILL.
Dia of Cyl 22^{ins} Stroke 42^{ins} 70 Revol.



Babcock & Wilcox Engine ROGER WILLIAMS MILL
Dia of Cyl 14^{ins} Stroke 4 feet 60 Revol.

But it should be remarked here, that the indicator diagram does not show the full quantity of steam used under any circumstances; as there is more or less water evaporated from the interior surfaces of the cylinder during the return stroke of the piston, while the exhaust valve is open, the steam from which evaporation does not show on the diagram, but nevertheless carries off a quantity of heat that has to be replaced by the condensation of more live steam, while the induction valve is open, on the return stroke, and this steam also is unrepresented upon the diagram. Again, there may be, and often is a leak from the cylinder either past the piston or exhaust valve, during the forward stroke, which may be detected by, but is not measurable upon, the diagram, although a leak into the cylinder is shown by a higher terminal pressure. There is, consequently, a quantity of steam used which it is impossible to estimate by means of the indicator alone, the effect of which upon this investigation will be considered hereafter.

Having assumed, therefore, that the terminal pressure represents a sufficiently near approximation to the quantity of steam used in developing the power represented by the diagram, we will proceed to construct a diagram of a theoretical engine of the same capacity, including clearance, as the engine under consideration, and having the same terminal pressure. But in order to do this, we must first know the pressure of steam in the boiler, and the clearance in the cylinder and passages. The former is generally given on the diagram, and, where practicable, should be corrected by testing the gauge with the indicator spring. The clearance is, however, rarely given, and varies in different engines from $1\frac{1}{2}$ to 10 per cent. of the space swept through by the piston in one stroke. If we have the drawings of the engine we can calculate it; if we know the style of engine we can approximate it; and if there is any compression, we can estimate it from the diagram, by assuming any two convenient points in the curve, measuring the pressure from absolute vacuum at those points, and their distance from a line vertical to the vacuum line, and touching the end of the card; thus in Fig. 1, let p = pressure and d = distance of the first point, or the one farthest from the end of the diagram, p' and d' = respectively the same quantities for the other point, and x = the clearance, then

$$(x + d)p = (x + d')p' \text{ and thence we have the formula } x = \frac{pd - p'd'}{p' - p}$$

p and d may be measured in any convenient scale, and x will be in the same scale as d . Or we may determine the clearance geometrically by the following construction; (see Fig. 2.) Assume two points A and B in the compression curve, and connect them by a right line A B, continuing this line until it cuts the line of no pressure, F E at E. Draw A D and B C perpendicular to F E, and make F D = C E. Then F is the end of the theoretical diagram including clearance, and the distance of F from the boundary of the indicator

diagram is the clearance in the scale of the length of the diagram, which represents the stroke of the piston.

Having determined the clearance, we proceed to lay out the theoretical diagram as follows: We first draw a line representing the boiler pressure, which is given in the scale of the instrument, and also a line of no pressure or perfect vacuum, at 14.7 pounds from the atmospheric line, unless the true barometric reading is given. We then divide the length of the diagram, including clearance, into a number of equal parts, generally ten, though any number will answer. We next measure the pressure at the point of exhaust, which is usually a little before the end of the stroke, and find the terminal pressure therefrom either by the inverse proportion of the distance from the commencement of the diagram to the whole length, or by the method shown in Fig. 3, in which AB is the length of the diagram including clearance, and the line of no pressure, and D is the point of exhaust. Draw DE parallel to AB , and join AE cutting DC at F . Then draw FG parallel to AB , and BG will represent the true terminal pressure, or in other words, the tension at which a quantity of steam equal to the whole capacity of the cylinder and clearance is discharged at the termination of the stroke.

Having thus found the terminal pressure, the pressure at any other point of the stroke is easily found by the usual formula, or what is known as Mariotte's law, in which the pressure increases inversely as the distance from the commencement of the stroke. Where there are ten divisions of the diagram, the several ordinates of the expansion curve may be obtained by multiplying the terminal pressure by the following series of numbers: 1, 1.11, 1.25, 1.429, 1.667, 2, 2.5, 3.333, 5, 10. Having found the theoretical pressure at each of the several divisions of the diagram, we then trace a curve through these points, and where the curve thus found intersects the line of boiler pressure, is the point of theoretical cut-off at which the admission of steam must be suppressed in our theoretical engine to give the same terminal pressure.

On the return stroke, if there is no compression, the theoretical diagram will follow along the atmospheric line or the line of absolute vacuum, according as the engine from which the diagram was taken is non-condensing or condensing, and will extend to the clearance line, and up that to boiler pressure. But if the exhaust valve closes before the end of the return stroke, and a quantity of steam is imprisoned in the cylinder to form a cushion, then so much of the cylinder full of steam as is thus imprisoned, is not discharged, but remains in the cylinder, and must be allowed for in our theoretical diagram. We therefore draw a hyperbolic curve tangent to the actual compression line, and extending to the line of boiler pressure, which curve forms the boundary of the theoretical "card." If the engine is condensing, this curve will also extend to the exhaust line, and will form the boundary of the theoretical diagram both on the bottom and at the end. If non-condensing the atmos-

spheric line will bound the diagram until it intersects the compression curve.

We now have two diagrams tangent at two points—the compression and exhaust—the one always larger and enclosing the other. The inner one represents what the steam actually performed in the engine, the outer one what the same amount of steam should have done in a perfect engine of the same capacity; and the proportion which the area of the smaller bears to the larger, gives a very good idea of the relative perfection of the mechanism which was used for developing the power of the steam. This may be expressed in percentage of the theoretical, and a collection of diagrams so figured, the arrangement of valve-gear in each case being fully noted, is very instructive.

To facilitate the construction of these theoretical diagrams, Mr. A. H. Raynal has devised the scales shown in Figs. 4 and 5. Fig. 4 is for laying off the hyperbolic curve of expansion with rapidity and without the mental effort incidental to mathematical calculations. It is simply a series of secants numbered from the vertical, whose tangents are to each other inversely as their numbers. In using this scale, which answers for all scales of pressure, and any number of divisions of the diagram, we take the terminal pressure in the dividers, or on a slip of paper, and find with which of the vertical lines it corresponds, at the secant corresponding with the number of parts into which the diagram is divided; and each of the other pressures will be found at the intersection of its corresponding secant with the same vertical line, and may be transferred directly to the divisions of the diagram. Should the number of divisions exceed ten, the dotted secants are used. They also serve for semi-divisions of the diagram, where accuracy requires them; as where the point of cut-off is quite early in the stroke. It is not essential to determine the terminal pressure in all cases, but frequently it will be sufficient to take the pressure at the 9th, or any convenient division, and from that point lay off the curve each way.

Fig. 5 is a device for laying off the divisions of the diagram, including clearance, the length of diagram and percentage of clearance to stroke being known. It is a diagonal scale with one of the divisions subdivided in a progressive ratio. In using it, the length of the indicator-diagram is taken on a slip of paper, and so placed upon the scale, that while horizontal one end rests upon the subdivision which represents the percentage of clearance, while the other end is at the extreme line of the scale; the several principal divisions of the scale are then marked on the slip of paper, the distance of the exterior line from the percentage subdivision mark being the clearance in the same scale as the stroke. Where the length including clearance is given, this scale is used simply as a proportional scale of parts. With this is given a scale of 14.7 pounds in various scales of pressure, a very convenient adjunct for laying down the line of no pressure or perfect vacuum.

Let us now consider briefly, the effect of condensation and leak-

age of the piston or exhaust valves; and whether these so modify the results obtained by this mode of comparison as to render it of little value.

Of course, any cause which lowers the terminal pressure, will decrease the size of the theoretical diagram in any given case, and thus give the engine a higher than its proper rate. Leakage from the cylinder produces this effect, and when this exists to any considerable extent, the diagrams are worthless for any other purpose than as a measure of power. As the amount of such leakage is not measurable upon the diagram, it is important, when diagrams are taken for the above investigation, or in fact for any purpose, that this point should be determined. This may be done by blocking the engine upon either half stroke, and letting on a full head of steam. By then examining the exhaust, the leakage, if any, will be detected, and may be measured by causing it to be condensed in cold water, weighing the water both before and after a given time; or by noting the rise in temperature of a given weight of water.

But the question of reëvaporation of condensed water within the cylinder while the exhaust-valve is open, is not so easily determined. It may be, and has been measured, by using a surface condenser weighing the water discharged therefrom and comparing it with the weight of steam exhausted, as determined by the capacity of the cylinder and passages, and the specific weight of steam at the terminal pressure, and has been found to vary from 9 to 50 per cent. of the whole amount of steam used, according as means for its prevention have been used or neglected.

This loss, if measured and accounted for in the theoretical diagram, would reduce the apparent rate of the engine; but as it is nearly the same in all cases, having the same amount of protection to the cylinder, and is in a measure independent of the mechanism of the engine, we may ignore it in the foregoing calculation, without seriously affecting the value of the latter as a means of comparing the efficiency of one engine with another. But we should bear in mind in such comparison, that the effect of this practically unavoidable loss is, in all cases, to belittle the performance of an engine having a good degree of expansion within the cylinder when compared with one having little or none; because, in the former, a portion of the reëvaporation occurs during expansion, and enters into our calculation. We should also remember that when a steam-jacket is employed, its usefulness is not fully apparent in this mode of comparison, for the principal benefit of the steam-jacket being to lessen the loss by condensation, and to increase the proportionate reëvaporation during expansion, the saving in condensation is not represented, while the increase of reëvaporation during expansion raises the terminal pressure, and thus lowers the percentage of the indicator diagram.

It will be seen that in this mode of comparing the performance of engines, the questions of the relative economy of expansion or non-expansion, of high or low pressure, condensing or non-conden-

sing, are not mooted; the comparison merely being as to the relative value of the mechanical arrangement for utilizing the steam used at the particular pressure, and degree of expansion, and under the circumstances which are employed in the engine. But it clearly shows why an engine which admits the steam at or near boiler-pressure, and automatically cuts it off at a point in the stroke proportionate to the load, is more economical than one which has a fixed or no cut-off, and a variable load, the power and speed being regulated by a throttle-valve. It also shows graphically the benefit of large passages and pipes, a tight, quick moving valve, and a proper amount of compression.

This mode of expressing the value of mechanical arrangements in steam-engineering, was first published, it is believed, in a pamphlet issued by the firm of which the writer is a member, about a year ago. As it was not practicable in the limits of an advertising pamphlet to fully elucidate the grounds upon which the comparison was based, and because many even among the profession do not seem to understand the mode of delineating the theoretical diagram, I have taken the present occasion to enter into a more explicit description and explanation of what I believe to be a new and interesting investigation.

In the foregoing, I have assumed that steam expands according to Mariotte's law, for the reason that were it a perfect gas instead of vapor, it would follow that law in its expansion, and it is not improper, for the purpose of comparison, to so consider it; while that law admits of a ready construction of the theoretical diagram without the necessity of tables or pressures, or the use of logarithms. But should any one prefer to use the modified law of expansion of steam deduced from the experiments of Regnault, the Franklin Institute and others, it can be done by employing the tables of pressures and volumes given in most collections of engineering formulæ. To facilitate this, I have constructed the scale shown in Fig. 6, which is a series of expansion-curves, as per such tables, laid down to different scales of pressures. The terminal pressure having been ascertained, the same is found on the curve having the same scale of pressure as the indicator diagram. The distance between that point in the curve and the line of no volume is then divided into as many divisions as there are in the diagram, and at each division will be found its corresponding pressure.

This curve may be also described by first finding the ordinates of a hyperbolic curve, based on a terminal pressure equal to the 0.941 power of the true terminal pressure, and then extracting the 0.941 root of each of these ordinates.

The curve thus found is always exterior to that derived from Mariotte's law, as is seen in Fig. 7, which is a diagram fully developed in accordance with the foregoing directions, and with both curves of expansion delineated. Several diagrams from various engines, compared in the foregoing manner are appended to illustrate the principle.

SOLAR ECLIPSE—AUGUST 7, 1869.*The Philadelphia Photographic Expedition.*

IN consideration of the fact that the services of all members of this party were entirely gratuitous, and that even much expense was saved to the Government by the loan of apparatus, and in other ways, through the means of its members, Prof. Coffin has given his consent to the publication of results obtained by them, in anticipation of their official announcement through his department. We are thus enabled, at this early date, to furnish our readers with a full account of all that was done by this expedition.—[ED.]

PHILADELPHIA, *August 18th*, 1869.

PROF. J. H. C. COFFIN, U. S. N.,

Superintendent of Nautical Almanac, Washington, D. C.

Sir:—On receipt of your letter of May 3d, in which you proposed that I should undertake the organization and conduct of a party to make photographic observations of the total eclipse of August 7th, I proceeded to make inquiry as to the material which might be available for the purpose and in concert with, and, assisted by yourself and Prof. E. O. Kendall, found that we might readily procure two fine Munich Equatorials of 6-inch aperture, and with clockwork, belonging respectively to the High School of this city and the Pennsylvania College at Gettysburg, and also an excellent Dolland of 4-inch aperture equatorially mounted, but without clockwork, belonging to the University of Pennsylvania in this city.

On further consultation with yourself, it was concluded that on account of the risk of local clouds, it would be desirable, if possible, to take all these instruments and distribute them over some distance on or near the central line.

On careful reflection, I came to the conclusion that at least five skilled operators would be necessary to each instrument, and that, therefore, something must be done to diminish the expense of transportation, or the government appropriation available for this department of the general eclipse observations, would be insufficient.

It also appeared that some arrangement by which trans-shipment of the numerous weighty and delicate pieces of apparatus might be avoided, would be highly conducive to success and security.



SOLAR ECLIPSE, AUGUST 7th, 1899.

I therefore called upon my friend, Mr. R. H. Lamborn, Secretary of the American Steel Manufacturing Company, whose extensive connection with our great lines of interior transportation would give him opportunity of affording the best advice, and explained to him my ideas. He went with me at once to Col. Thomas A. Scott, Vice-President of the Pennsylvania Central Railroad, and stated the case to him with admirable brevity and precision.

Col. Scott, with the greatest kindness, acceded at once to our request, and promised to provide us with a special car, from which some seats should be removed to accommodate our apparatus, and which should go with us to the end of our route, and there remain until our return. Free transportation over the entire route of the Pennsylvania Central and Ft. Wayne Railroads (*i. e.*, as far as Chicago,) for our party, and several others beside, was included in or added to this generous gift.

I then wrote to Mr. Robert Harris, of Chicago, General Superintendent of the Chicago, Burlington and Quincy Railroad, asking him to forward our car and its contents over the road in his charge. To this he also most kindly agreed, and, in fact, facilitated our movements in every way, sending a locomotive to meet us at the intersection of his road with the Pittsburgh, Fort Wayne and Chicago line, and carrying us to the depot for Burlington on our way out, when we were pushing through rapidly, and transferring our vehicle again on our return journey. Mr. Norton, from Mr. Harris' office, also met us at the junction, to explain the proposed disposition, and kindly acted as our guide through the city.

Provision being thus made for transportation, by which an expense of about \$15,000 was spared to the government appropriation, the plan of taking out a triple party became feasible, and was accordingly adopted.

The next point was the selection of the party, and this was proceeded with at once, communications being exchanged with many of our leading photographers and others, to learn their views and inclination. It was soon found that an excellent selection might be had from among those whose position or engagements would allow them to volunteer without other compensation than the moral one contingent on success; and after a few changes, rendered necessary by sickness or other inevitable cause, the party, as finally constituted, consisted of Prof. A. M. Mayer, Ph. D.; Prof. C. F. Himes, Ph. D.; Messrs. J. Zentmayer, O. H. Willard, E. L. Wilson,

H. C. Phillips, E. Moelling, J. C. Browne, W. J. Baker, James Cremer, H. W. Clifford, O. H. Kendall, J. Mahoney, W. V. Ranger.

We were also joined, as volunteers, on the ground, by Mr. John Corbutt, of Chicago, and Mr. Miles Rock, of Bethlehem, Pa., and Mr. Leisenring, of Burlington. Prof. Coffin having suggested that some general physical observations should be carried out in connection with this party, I applied to Prof. E. C. Pickering, of the Massachusetts Institute of Technology, Boston, who consented to take charge of these, and accompanied us to Mt. Pleasant, Iowa, as will be seen from a subsequent portion of this report. Prof. James McClune, of the Philadelphia Central High School, and Prof. S. G. Gummery, also accompanied the expedition, and were stationed at Oscaloua.

The next point to which attention was directed, was the arrangement of the instruments for their photographic work. It was a question of much moment, to decide whether we would follow the plan adopted by the French and German expeditions of last year, and make the photograph in the principal focus of the object-glass, thus securing great intensity of light in a small image, or follow the method employed by De la Rue in 1860, when he used an ordinary Hygenian eye-piece so placed as to produce an enlargement of the first image from the objective.

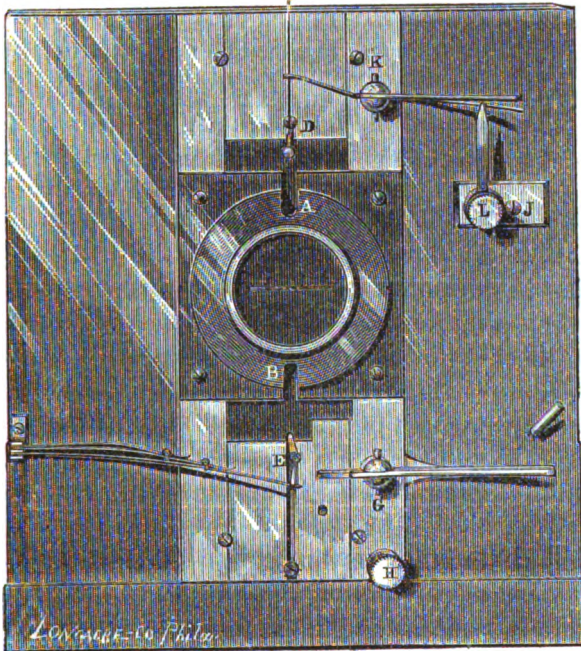
After a careful study of De la Rue's report and pictures, as also those of the later expeditions, I came to the conclusion that the plan of enlargement presented many advantages, and should be followed by us with certain modifications, which I will proceed to describe.

The work of designing and constructing these lenses, and also the different attachments to the cameras for securing exposures of various degrees of rapidity from a very small fraction of a second to any desired length, was placed in the hands of Mr. Joseph Zentmayer, whose extended scientific attainments, combined with unrivalled skill in the construction of optical instruments, peculiarly fitted him for such a task.

The camera, as finished, is represented in the accompanying woodcut, which shows it as seen from directly in front.

Here *AB* represents the face-plate of the camera, to which the eye-piece tube was attached, its other end being screwed to the telescope. The diaphragm plate, *DE*, moved across the axis of the

instrument, being drawn downwards by the combined spring, EF. The strength of this spring could be reduced by raising the outer end of one or both the upper strips so as to disengage the forks at their end from the lower spring, and then turning them forward in a direction normal to the front of the box, out of the way.



The spring was attached to the diaphragm plate by a swivel hook, which, while in no instance falling out, could be detached and readjusted with the greatest facility.

A number of diaphragm plates were provided, with slits respectively of $\frac{1}{4}$ in, $\frac{3}{8}$ in, $\frac{1}{2}$ in and $\frac{3}{4}$ in of an inch in width. These plates could be readily interchanged, and, in combination with the springs, gave a very wide and yet delicate series of fixed adjustments for the times of exposure.

To make the exposure, the plate was drawn up until the projecting pin, D, could be caught on the lever, K, which would then retain it. On depressing the outer end of this lever, however, with the finger, the hold on the pin was disengaged, and the plate flashed across the axis of the tube, allowing light to traverse the narrow slit as it flew past. The plate was then arrested on the end of the

second lever, g. When an exposure of some seconds was required, as during the totality, a plate having a round orifice exposing the entire field of the eye-piece was substituted for the one with the narrow slit, and was so arranged that, when caught by the upper lever, it covered the lens, but when fallen to the second lever, exposed it entirely; when, however, this lever was in turn touched, the plate descended again far enough once more to close the lens. By touching these two levers in succession, it was then possible to make a "time exposure" with great nicety and accuracy, as proved by actual experience during the eclipse.

To secure a chronographic record of each exposure, a binding screw was provided to make one connection with the general mass of the face-plate including lever k, and another at l, to carry on the circuit when the downward motion of the lever brought the spring at its side in contact with the point projecting from l. In raising the lever for a new exposure, the spring at its side was pressed back so as to pass the point without contact. A more substantial break-piece would have been made, had time allowed, but this was found to operate in a perfectly satisfactory manner.

As the operation of the eye-piece, when employed to produce an image on the screen or ground glass of a camera, is essentially different from that which it performs in its usual office, it was judged best, by Mr. Zentmayer, to make some alterations in its form. Thus, in the first place, since in the present case the "eye-lens" of the eye-piece undoubtedly makes a secondary image of the primary image formed within the eye-piece by the combined action of the objective and the field lens of the eye-piece, it is clearly desirable to make this lens of a longer focus than usual, so that its errors may be of less account. It was also essential to give the new eye-piece a wide angle, so as to secure a sufficient field not only for the solar disc, but also for the corona.

While, therefore, the ratio of focal lengths in the two lenses of the ordinary eye piece is usually 1.3, it was, in this case, as 1.2. While the distance between the lenses is usually the sum of their focal lengths divided by 2, it was here made equal to the sum of the focal lengths divided by 2, plus .24 inch. This was to give space for the introduction of the reticule of spider lines which would otherwise have been brought too near the field lens, and also to keep this lens beyond the conjugate focus of the eye lens,

as otherwise particles of dust on the former would have been too faithfully portrayed by the latter.

The elements actually adopted were as follows :—

	ft. in.
Focal length of Objective.....	8 6
Radius of Field Lens.....	1-875
“ Eye Lens.....	0-687
Focus of Field Lens.....	2-6
Diameter of Field Lens (= R).....	1-875
Focus of Eye Lens.....	1-8
Diameter of Eye Lens (= R).....	0-687
Distance between Lenses, $1-95 + 0-25$	2-2
Equivalent.....	1-75
Distance of Reticule from Eye Lens for 5-inch distance of ground glass.....	1-62

The reticule was mounted on a short tube with a fine thread on the outside running in a corresponding thread on the inside of the eye-piece tube. This being approximately adjusted beforehand, was moved to its exact place by turning it with a sharp point through a little slot cut in the eye-piece tube.

One of the cameras with its eye-piece, being finished, experiments were at once made with the telescope of the University of Pennsylvania, which by reason of its smaller size, was most readily available for such purpose. These were conducted by Mr. Willard, Mr. Zentmayer, and myself, at the establishment of Mr. Willard, 1206 Chestnut Street, where all conveniences for the work were at hand, and were of the greatest value in affording data on which the construction of the other apparatus could be based.

It was found that, with a clear sun, it was necessary to reduce the aperture of this telescope (which was 4 inches, with 50 inches focus,) to $1\frac{1}{2}$ inches, and to use all three springs and the diaphragm-slide of $\frac{1}{8}$ inch aperture, in order to get a proper exposure when the solar image was enlarged from '6 inch (its diameter at the principal focus of the objective) to $2\frac{1}{2}$ inches on the ground glass. The same size of aperture was adopted for the larger instruments during the partial phases, the entire aperture, in all cases, of course, being used during totality.

There being no place in the city where the larger instruments could, with convenience, be set up, adjusted, and practiced with by the party who were to use them, I applied to Mr. John Sellers for permission to use a very conveniently located portion of his grounds

in West Philadelphia, and having prepared a design for a temporary building, (with roof, in part, removable by sliding,) caused it to be erected, and had the large instruments set up in it.

Matters being thus far advanced, Prof. A. M. Mayer, Ph. D., of the Lehigh University, Bethlehem, Pa., who had agreed to join our party, came down to the city and spent some days here, during which the telescopes were adjusted by him, in a very perfect manner, by a rapid and convenient method, which has been made the subject of a full discussion by him, as will be seen in his own report appended hereto.

A number of experiments were made by Mr. Willard, at this time, in photographing the moon, which were of great value in settling the time of exposure which would probably be required in the total phase.

He found that a good impression could be obtained of the full moon in about one minute, and that an abundantly strong one could be secured with an exposure of three minutes. From this and the deductions of De la Rue, that the light of the prominences was 180 times as great as that of the full moon, it appeared that an exposure of from $\frac{1}{3}$ of a second to 1 second, during totality, would have been sufficient to secure images of these bodies. For the corona, of course a much longer exposure would be required; but no estimate could be made as to what would be its duration.

In connection with these experiments, it is but just that I should call attention to the unwearied patience and enthusiastic energy with which Mr. Willard devoted himself to the prosecution of this preliminary work. Day and night, whenever any observations were to be made, or any experiments tried, he was on the ground, and on certain occasions displayed an energy and determination, combined with sound judgment, seldom to be encountered. Thus, it becoming desirable to shift the position of the building in which the telescopes were placed, he arranged and accomplished this in a most successful manner, though the operation was considered, by the professional builders present, impossible without derangement of the instruments.

Mr. O. H. Kendall also rendered invaluable services in connection with the preliminary arrangements.

Much interruption was experienced from bad weather after this, but the rainy days were utilized by Mr. Zentmayer in putting the driving clocks of both instruments (which were in very bad order)

in admirable adjustment, so that, on the few occasions that the sun *did* shine, enough work was done by the rest of the party to make them familiar with the necessary manipulations.

The instruments were dismounted, boxed, and packed in the special car furnished us by Col. Scott, on Saturday, July 31, when it was found that, with the various photographic appliances, they made no less than five furniture car loads of material.

On Monday, August 2d, we started, and on Wednesday, the 4th, about noon, reached Burlington, Iowa, on the bank of the Mississippi.

In arranging the division of our party into three sections, with the three telescopes, so that they might be distributed along the line of totality, and thus diminish the chance of universal extinction by local clouds, I was chiefly guided by the desire of securing in each section such a diversity of special ability as might make each self-dependent and complete; also, to leave nothing undone to secure content and harmony of feeling. I assigned myself to the University telescope, which, being of smaller size, and without clockwork movement, could not be expected to do as good work as the others; though, should *they* by chance be overclouded, *its* result would be invaluable.

I therefore divided the party as follows:—

With the High School telescope, 6-inch aperture, 9 feet focal length, Prof. A. M. Mayer, Ph. D., and Mr. O. H. Kendall in charge of the adjustment of the instrument and management of the apparatus for exposures, and Messrs. O. H. Willard, H. C. Phillips, and J. Mahoney having charge of the entire photographic work. This section was stationed at Burlington, $40^{\circ} 48' 17''$ N., 0 h. 56 m. 14 s. West of Washington.

With the Gettysburg telescope, 6-inch aperture, $8\frac{1}{2}$ feet focal length, Prof. C. F. Himes, Mr. J. Zentmayer, and Mr. E. Moelling in charge of the instrument, &c., and Mr. J. C. Browne and Mr. W. J. Baker, who managed all the photographic processes. This party was stationed at Ottumwa, about seventy-five miles nearly west of Burlington.

With the University telescopes were Mr. E. L. Wilson and myself, in charge of the instrument, and Messrs. H. W. Clifford, James Cremer, and W. V. Ranger, as photographers. We were also joined by Mr. John Carbutt, of Chicago, as a volunteer, who gave us most efficient aid. This section was placed at Mt. Pleasant, be-

tween the other stations. The various parties having reached their destinations during Wednesday, arrangements were at once made to get the instruments into position in the locations previously prepared by Prof. Coffin. In the case of the Burlington party, all went smoothly, and the dark weather alone prevented final adjustment until the night of the 6th or morning of the 7th, when this was secured with great nicety by Prof. Mayer, who sat up all night for the purpose.

With the Ottumwa instrument it was, however, found that the clockwork had become seriously deranged in carriage, so that Mr. Zentmayer was obliged to take it entirely apart and refit it. This he accomplished with great success, and it may be regarded as one of our many pieces of providential good fortune, that since one of the clocks was to go wrong on the journey, it was that one which was within reach of this gentleman's skill. The trouble and anxiety which this cause of delay occasioned, was, however, no small trial of fortitude to the Ottumwa party. The final adjustment was also given to this instrument during the morning of the 7th, by Mr. Zentmayer, who had watched all night, vainly, for a star.

This party, beside the above-mentioned difficulties, were unable to obtain any expert assistance on the ground, from resident photographers and others, as was done by both the other divisions, so that they were left entirely to their own resources, and acquitted themselves, under the exceptional difficulties of their position, in a most creditable manner.

In this connection, special reference should be made to Prof. C. F. Himes, who, by his skill, judgment, and coolness in a serious emergency, (occasioned by accidental derangement of the chronograph attached to the telescope,) preserved the record of this series of pictures which must, otherwise, have been in great part lost.

The telescope at Mt. Pleasant having no clockwork, and being otherwise unfit for any fine adjustment, required no arrangement, except what could be given during the morning of the 7th.

As all know, the weather on the eventful day of the eclipse was, at all our stations, perfect, so rendering needless, but none the less judicious, our policy of distribution.

At the Burlington station, a photographic record of the first contact was secured, by exposing plates, in rapid succession, about the calculated time. A very good result was thus obtained.

At Mt. Pleasant, we placed a plate ready in the camera, and then

waited a signal from Prof. Watson, of the University of Michigan, who, with his party, was on the ground with us, and was watching for the first contact. We thus obtained a picture showing a very slight indentation. By measurement of this, the time of *actual* first contact can be reached by calculation, yet more precisely than would be possible with any eye observation.

During the partial phases, accurately timed exposures were made by all parties, at intervals varying from a few seconds to ten minutes.

Partial-Phase Pictures.

These pictures show the various sun-spots visible at the time (about six in number) with admirable definition, the larger ones being surrounded by a marked fringe of faculæ, and give, also, a distinct granulation over the general surface of the sun.

They all show an increase of light on the solar surface, where it is in contact with the edge of the moon. This, which would seem to indicate, according to Prof. Challis*, the presence of a very rare lunar atmosphere, is unmistakably manifest on all the negatives, and confirms the observation made by Prof. Stephen Alexander, in 1831 and 1860, when he noticed it on the photographs that were then taken.

De la Rue observed something similar in 1860, which he considers a subjective effect; but this explanation will clearly not apply to the present case, where it is evidently a question of deposited silver, and not contrast of light and shade.

Totality Pictures.—The Prominences.

During the totality thirteen pictures, in all, were taken with the three instruments. Of these, six were made at Burlington, with exposures of five to seven seconds; four were made at Ottumwa, with times of exposure ranging from six seconds to sixteen.

These are all admirable negatives, which show abundant detail, and, in some cases, much of the corona. Three pictures in totality were also made at Mt. Pleasant, but, for want of a clock-movement, are inferior to the others. One of the Ottumwa pictures, exposed at the very last instant of totality, shews a photographic record of the curious phenomenon known as Bailly's beads, being simply the last glimpse of the sun's edge cut by the peaks of lunar mountains into irregular spots.

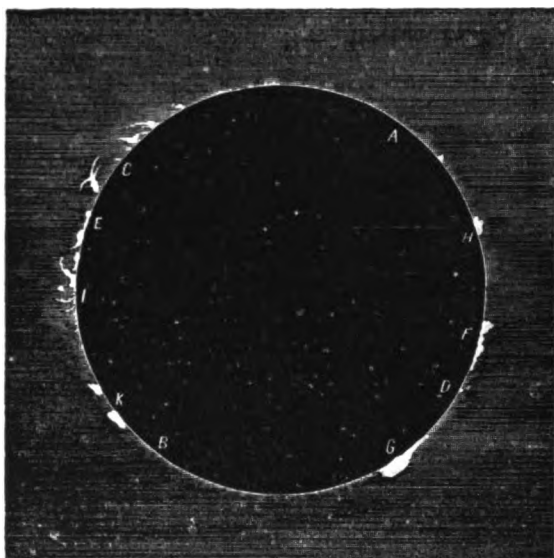
One of the objects which it was considered desirable to secure, if

* See *Monthly Notices* of the Royal Astronomical Society, 1863, p. 234.

possible, was a view of the corona. It was with this intent that some of the exposures were made so long.

Examination of the negatives shows us that five seconds was more than sufficient to secure all the details of the protuberances, although it gave no decided indication of the corona.

The development proceeded slowly in all but a few spots where very massive prominences were located, and thus it was not thought, at the moment, judicious to try shorter exposures; but, in the light of our present experience, we would judge that exposures of even one or two seconds, with persistent development, such as could be best carried out on albumenized plates, would be of value to secure details in the rounded and massive prominences which appear at some points.



It is a curious coincidence, that in this case, as well as in the pictures made by De la Rue, in 1868, and the German and English party last year, all the more interesting prominences are situated on the border of the sun furthest from the advancing moon, and are thus best shown in the pictures first exposed. Thus, we have selected half of the first totality picture taken at Burlington, to be used as an illustration in this place, as enabling us to give it a large size without exceeding the limits of our page, and yet secure nearly all that is of interest.

The most conspicuous prominence is that which, at a hasty glance, seems to resemble the letter X, but, on more careful inspection, is perceived to be like an ear of corn. It consists of a solid central mass inclined at an angle of about 45° to the normal at the solar surface, and with three branches from near its upper end, one sweeping backwards in a direction generally parallel to the solar surface, another forward, as concerns the direction of the general mass, and a third branching out a little below and running in the same direction as this last. The appearance of the main body, which is of a spindle shape, and with spiral markings, is highly suggestive of a vortical motion which has swept these whiffs of light matter into their peculiar positions.

It was believed by several observers, that this object moved rapidly while they were watching it; but as the same positions are shown in the eight different negatives, (taken at Burlington and Ottumwa,) which contain it, there can be no doubt of its permanent character.

It appears, however, beyond doubt that motion, amid the light surrounding the sun, was observed, as there is much accordant testimony on the subject. But this motion, as we shall presently see there is every reason to believe existed in the corona, and not in the prominences, which, however, might easily have the appearance of movement, if seen against a background of shifting light. To this subject we shall refer again when speaking of the corona.

Immediately to the right of this ear of corn, is seen a region of soft light, among which rise two similar spindle-shaped masses inclining towards the corn ear.

To the left appears a mass of rolling cloud disposed in beautiful streams and curls, like the smoke from a bonfire or burning meadow, swept gently toward one side by a light wind. In connection with these are some small masses, entirely detached and floating above the general body, as was the case in De la Rue's pictures.

Other solid nodular masses appear at other points; but the next most notable prominence is one which attracted the attention of all observers, and appeared to occupy a position on the lowermost edge of the sun. It is most clearly shown in the last pictures taken at each station, and resembles, in shape, a great whale with a body made up of dense cumulous cloud matter, with a long tail clinging close to the solar edge, and stretching some 40,000 miles along. The length of the entire mass is about 110,000 miles, and

the height of its more bulky portion about 28,000 miles, while its length being about 70,000 miles, we would have for its cubic capacity, assuming that its extent in the remaining direction is equal to its height, about 54,880,000,000,000 cubic miles.

To the right of this, and only showing its entire length in the last picture of each series, is a caterpillar-like mass of cloud matter, very much like the solid rolls of horizontal vapor which are sometimes seen passing over a sheet of water. At one end rises a projecting head, but the rest clings closely to the solar edge, and is indented with ring-like divisions, giving it much the aspect of a huge worm.

The Corona.

The Ottumwa pictures, of long exposure, are the only ones which give us any idea of the true structure of the corona, but they do more than I had hoped in this respect. One of them, the last and longest exposed, gives almost as full a development to this object as I remember to have noticed with the naked eye; the curved structure of the rays, and the varying intensity with which they are emitted in different points, is most marked.

The brightest outbursts of the corona light are evidently associated with those prominences which are of a pointed and flame-like shape; those of a massive description, on the contrary, seeming to cast a shadow on the corona; this, we think, is to be noticed in De la Rue's pictures.

These facts have peculiar significance, when taken in connection with others developed by observations made during this same eclipse. In the first place, Prof. E. C. Pickering, of the Massachusetts Institute of Technology, who was with our party at Mt. Pleasant for the purpose of making various physical observations, found that while the sky was strongly polarized all around, close up to the corona, that object itself was not a source of polarized light.

The instrument employed was a tube, having at one end a large plate of quartz, and at the other a double image prism of Iceland spar, made in the manner known as the prism of Rochon.

On looking through this at the corona, the entire circle was in field with a part of the surrounding sky, and two entirely distinct images of the entire area were seen, the corona in both being colorless, but projected on a ground of tints, complementary in the two images.

This would certainly indicate that the light of the corona was not reflected sunlight. With a spectroscope arranged to analyze the entire light from the totality phase, Prof. Pickering also found no dark lines in the spectrum. This also points in the same direction.

The observations of Prof. C. A. Young, of Dartmouth College, Hanover, N. H., who was stationed at Burlington, are most conclusive. He found bright lines in the spectrum of the corona corresponding with those given by the aurora. In a letter which I have just received from him, he says:—

"Since returning, I have seen the last (July) No. of Silliman, and in it the positions given by Winlock for 5 aurora borealis lines.* You will be interested to learn, that so far as I can ascertain by graphical construction, the aurora line at 1550 of Huggins' chart exactly coincides with my principal corona lines 1474 Kirchhoff; and, moreover, the aurora lines 1280 and 1400 (Huggins), agree, as far as I can judge, with the two fainter corona lines between D and E, which I saw and recorded, but had not time to measure accurately.

"Perhaps I am too bold in my conclusions, but at present I feel persuaded that the *solar corona is a permanent aurora*.

"All three of these aurora lines are given by Angstrom as *iron* lines. What is the meaning?"

It would thus seem almost certain that the corona is simply an electric discharge, no doubt varying with great rapidity, as we see in the case of the aurora, and to its variations we may attribute those apparent motions of the prominences which have been observed by so many, but which our large series of photographs so conclusively shows not to have had any actual existence.

Appearance of Meteoric Shower.

At the Ottumwa station, a curious appearance was noticed by Mr. Zentmayer, and also by Prof. Himes, as will be seen from his report.

* *Silliman's Journal*, Vol XLVIII., p. 123. "We are indebted to Prof. Winlock for the following interesting notices. The light of the beautiful Aurora of the evening of April 15th, examined with the spectroscope, gave five bright lines corresponding in position to the following lines of Mr. Huggins' scale. 1280 (brightest), 1400, 1550, 1680 near *r*, 2640 near *g*. On the evening of June 6th, the same lines were again observed, the brightest corresponding with 1280 of Mr. Huggins' scale. These lines could readily be seen and measured with an ordinary chemical spectroscope, with the collimator pointed directly towards the heavens."

During the time that the pictures of the partial phase were being taken at long intervals, the ground glass plate was put in the camera to note any irregularities in the clock movement, should they occur.

About twenty-five minutes before the totality, Mr. Zentmayer ob-



served some bright objects on the ground glass, crossing from one cusp to the other of the solar crescent, as indicated in the accompanying cut by the lines from A to B. Each object occupied about two seconds in passing, and they all moved in right lines, nearly parallel, and in the same direction.

These points were well defined, and conveyed to the mind of Mr. Zentmayer, who is accustomed to the use of the camera for photographic purposes, the strong impression of being images of objects, and not points of light merely.

It is, moreover, certain that the objects, whatever they might be, must (in order to have produced such sharply defined images on the ground glass) have been several miles distant from the telescope, as even a point of light at a less distance would have produced an image enlarged and with a hazy border.

After calling Prof. Himes' attention to this phenomenon, and observing the motion of some eight or ten bodies in all, Mr. Zentmayer then noticed three others coming in from the limit of the field and disappearing in the solar crescent, as shown at C, but not reappearing on the other side.

It is worthy of note, that the direction of motion in the three last of these bodies corresponded with that of the wind blowing at the time, but that of the others did not, and they are thus, as also for other reasons, unlike the plant seeds noticed some years ago by Rev. W. R. Dawes, and described in a paper published in the *Monthly Notices* of the Royal Astronomical Society for 1852, page 183.

We consider it right, however, to record the observation made by our party, as other observers, in very distant locations, have noticed phenomena, which, according to the very general report as yet published, must bear some close relation to these, and this confirmation and additional data may thus aid in some valuable deduction. If these were meteoric bodies between us and the moon, and

also beyond our satellite, their probable appearance would not be inconsistent with the observations recorded.

Before closing this report, I cannot refrain from saying a few words in reference to the members of my party.

Our labor was eminently a coöperative one, and the pleasing success which has attended our efforts is largely due to the thorough harmony of effort and the self-denial and devotion to the general cause, irrespective of individual interest, which has characterized the entire history of this expedition.

The work we had in hand was of a nature which, in the first place, required the combination of a high order of ability in many distinct branches. It was necessary that the best optical skill should be enlisted in the structure and arrangement of the lenses;—it was essential that the very best mechanical ability should be applied to the details of the various adjustments of clockwork and cameras;—the largest experience in photographic operations was equally necessary;—so, also, was a thorough and ready skill in the refined details of practical astronomy. Besides this, it came of necessity that the failure of any one would ruin the work of all, as each step must be secure, or the pinnacle of success could not possibly be reached.

Under these circumstances, when we say that we have no failure to regret, and that no reproach has had cause to be uttered, the highest commendation possible has been implied towards all and every one concerned.

Where all were unremitting in effort and excellent in execution, it is not easy, without injustice to any, to indicate the special merit developed by opportunity or trying emergency in some; but we cannot refrain from drawing especial attention to the very valuable aid which was afforded by Prof. Mayer, Ph. D., through his intimate familiarity with all the niceties and most refined improvements in practical astronomy; by Mr. Joseph Zentmayer, through his admirable ingenuity in the devising and construction of the various mechanical and optical details required in the several instruments; by Mr. O. H. Willard, through the unsparing devotion of time and energy, and the indomitable perseverance by which all the preliminary arrangements were pushed to a successful issue, and his own department developed to its highest perfection; and by Prof. C. F. Himes, through the sound judgment and presence of mind displayed on a trying and sudden emergency.

While affording gladly this special distinction to some, we repeat that all were equally meritorious, and that the work of no one would have been of the least value without the aid of the others.

I have also, on my own behalf, as well as on that of my colleagues, to thank you for that uniform kindness, courtesy, and consideration which has rendered all our relations of the most agreeable character, and made our labor of love in an equal degree a labor also of pleasure.

Very respectfully yours,

HENRY MORTON.

NOTE.—The reports from those in charge of the several departments will be published in the next number.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, June 16th, 1869.

THE meeting was called to order with Mr. Coleman Sellers, Vice-President, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported the donations to the Library received at the stated meeting held June, 9th inst., from the Royal Astronomical Society, the Royal Geographical Society, the Institute of Actuaries, the Statistical Society, and the Society of Arts, London; and the Association for the Prevention of Steam Boiler Explosions, Manchester, England, l'Ecole Imperial des Mines Paris, and la Société Industrielle, Mulhouse, France; the Canadian Institute, Toronto, Canada; the Mechanics' Institute, San Francisco, California; Prof. Alfred M. Mayer, Bethlehem, Pa., and Prof. John C. Cresson, Philadelphia.

The various Standing Committees reported their minutes.

The Resident Secretary presented his regular report on Novelties in Science and the Mechanic Arts.

After a general discussion of several points, in which Mr. Robert Briggs, Mr. Thos. Shaw, Professor R. E. Rogers and others took part, the meeting was on motion, adjourned.

HENRY MORTON, *Secretary.*

Errata to Report on Eclipse.—Owing to some unexpected delays with engravings, &c., the foregoing report was finally printed without sufficient care in revision of proofs. Some errors and omissions have thus been overlooked.

Page 201, line 28, for \$15,000 read \$1,500.

“ 202, “ 13 “ Gummery read Gummere.

“ “ “ 14 “ Oscaloussa read Oscaloosa.

“ “ “ 22 “ Hygenian read Huygenian.

“ 209, “ 35 “ last instant of totality, read, last instant before totality.

Page 213, line 24 for lines read line.

It should also have been explained that the woodcut on page 210 represents the general character and relative positions of the prominences shown on *all the photographs*, some being visible only on the early, others only on the later pictures. The lines A B and C D give the directions of the spider lines used in the telescope, and placed carefully in line with a parallel of declination and at right angle to the same, respectively, by observations on a sun-spot before the beginning of the eclipse. The line F E represents the direction of the moon's motion across the sun from first contact at F to last contact at E.

The prominence described as resembling an ear of corn is that between c and e on the woodcut, page 210, those about I resemble wreaths of smoke, those above c look like flames. These two portions were those that in the telescope looked like simple obtuse pyramids of white light capped with rose color, [See Items at the beginning of this Number.] II was the prominence which in the telescope looked like a mushroom. F was the one at the point of first contact seen by Prof. Young beforehand with the spectroscope and used in his beautiful determination of first contact with that instrument. G is the whale-like prominence. [See Items at the beginning of this Number.]

With reference to the photographic illustration, inserted in the foregoing report, it must be remembered that in the double copying required, and by reason of the rapid wholesale process of printing rendered necessary for a large edition, some of the more delicate details are lost. This is especially notable in the spindle-shaped prominence near the middle of this picture. On the original and on carefully prepared prints it shows three cloudy sprays or branches from its upper end having the positions indicated in the woodcut on page 210 between c and e. Much of the soft fringe of light surrounding all these large groups of prominences is also lost.

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Burlington, Iowa, October 2d, 1887.

DEAR SIR: I take this occasion to state to you, that for several years past I have been acquainted with the manner in which you have conducted your business as Patent Solicitor. This has always been highly creditable to yourself and satisfactory to the Patent Office. You understood your cases well, and presented them in that intelligible form which generally insured success. I make this Certificate in hopes that it may be serviceable to you in continuing to find that employment in your profession to which your industry, intelligence and courteous bearing so justly entitle you.

Yours, very truly,

CHAS. MASON, Late Commissioner Patents.

To HENRY HOWSON, Esq.

Boston, October 12, 1888.

MY DEAR SIR: It gives me great pleasure to give my testimony as to the manner in which you conducted your business as a Solicitor of Patents, during the four years that I was Chief Clerk and Executive Officer of the U. S. Patent Office, and for a considerable period Acting Commissioner.

During that time your business at the Patent Office was surpassed in extent but by one firm in New York. The papers presented by you, specifications, drawings, correspondence, &c., were invariably models of neatness, accuracy and legal precision. They were frequently pointed out to younger solicitors as among the best examples and precedents for practice in the office. Your intercourse with the office was so conducted that all the rights of your clients were secured without personal controversy. With the best opportunities of judging, I do not hesitate to say, that your thorough knowledge of mechanics and patent law places you in the first rank of the Solicitors of Patents of the United States.

Very truly, yours,

JOHN L. HAYES, Late Chief Clerk and Executive Officer U. S. Patent Office.

H. HOWSON, Esq., Philadelphia, Pa.

Washington, D. C., November

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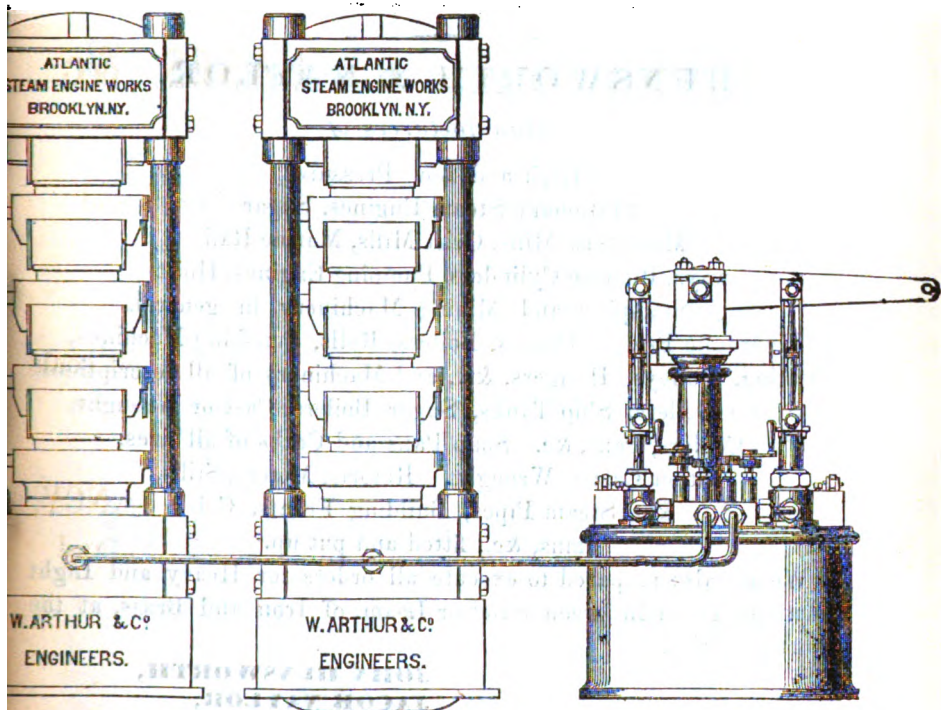
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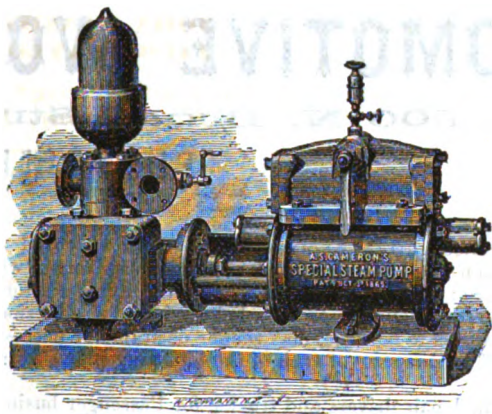
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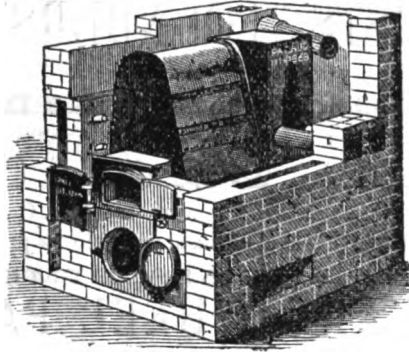
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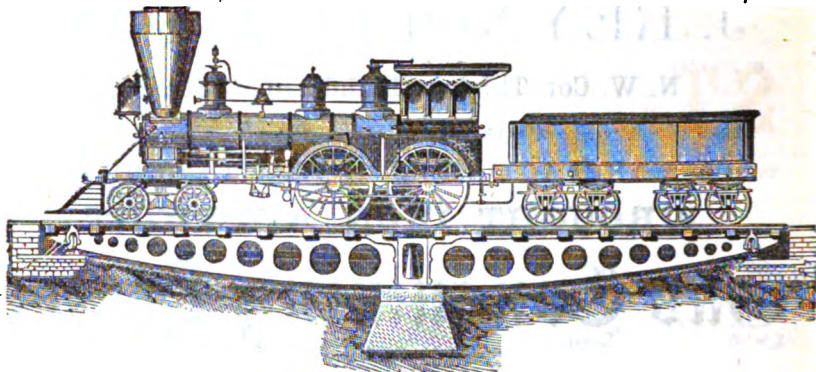
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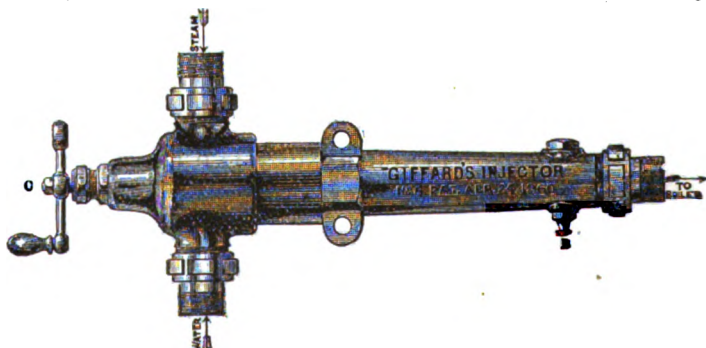
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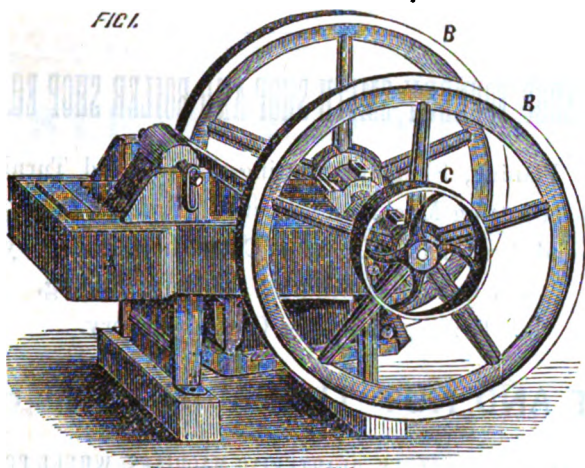
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[No. 4

EDITORIAL.

ITEMS AND NOVELTIES.

Louisville Bridge.—The bridge to span the Ohio River at Louisville, Ky., is being rapidly pushed to completion, and is now so far advanced that the engineers are confident that trains will cross early in November next. The first stone on this bridge was laid August 1st, 1867, since which time the work has steadily progressed. There are 27 piers and 4 abutments (including 2 abutments at crossing of Jeffersonville and New Albany Railroad) containing in the aggregate 81,000 cubic yards of stone. This masonry supports an all-iron superstructure having a total length of 5,280 feet, and composed of spans varying in length from 50 to 400 feet, these are arranged in the following order, commencing at the Kentucky end, viz: two spans of 50 feet, one draw span over Louisville and Portland Canal of 264 feet, four spans of 150 feet, two spans of

180 feet, two spans of 210 feet, two spans of 227 feet, one span of 370 feet (over grade), six spans of 245.5 feet, one span of 400 feet, (over grade), three spans of 180 feet, one span of 150 feet, and one span of 100 feet reaching Indiana abutment, also one span of 49 feet in continuation of embankment over Jeffersonville and N. A. R. R.

The grade of rail approaching the bridge on Kentucky side is elevated four feet above that at point of crossing on High Street, from which street it ascends at the rate of 76 feet per mile, striking the first span of bridge at an elevation of 61 feet above low water, and continuing the same till it reaches the Kentucky end of the 370 feet span over the middle channel, where it has an elevation of 95 feet above low water in this channel. From this point the grade is level to the Indiana end of the 400 feet span, which spans the Indiana Channel (a distance of 2,243 feet) at this point. The grade line is $101\frac{1}{2}$ feet above low water (low water mark being $6\frac{1}{2}$ feet lower than in middle channel). The grade from here descends at the rate of 76 feet to the mile, reaching the northern abutment 35 feet above surface of ground; the grade of Indiana approach continues to descend at same rate, reaching the surface at a distance of 2,500 feet from abutment.

The superstructure is placed below grade except where it crosses the Middle and Indiana Channels.

All of the piers are finished but four, and these are so well advanced that they will be finished before required for the superstructure. This is being raised at both ends; on the Kentucky side the 370 feet span has just been completed, and one of the intermediate 245.5 feet spans is being erected, on the Indiana side the 400 feet span is in process of erection.

The undergrade portion is of the plan known as Fink's Suspension Truss, while the channel spans are of the triangular plan as arranged by the same gentleman, the 370 feet span is the longest iron truss yet erected in America, and is of wrought iron, excepting the top chords and brace pedestals, they being of cast iron. The braces and posts are of Phoenix wrought iron columns varying in diameter from 5 to 17 inches, according to the position they occupy in the structure.

The 400 feet span is entirely similar in detail and arrangement. The undergrade portion has its top chords, floor-beams (arched, with a tie), and post pedestals of cast iron, the remaining parts are of wrought iron, the posts being of Phoenix columns.

This bridge will be arranged for the accommodation of both railroad and carriage traffic, with a foot-walk on either side, all on the same floor. The railroad track will be laid in the centre with an outside rail on either side, one rail of the railroad track forming with each outside rail a double street railroad track.

No street cars or vehicles can cross at the same time as a locomotive, but street cars and common carriages can pass each other at any place on the bridge. Both masonry and superstructure are being constructed by the Bridge Company, the former having been given over by the original contractors, and the latter being delivered ready for erection at a price per pound, all drawings being furnished by the engineers of the bridge.

This great work has been planned by, and is being carried out under, the supervision of Messrs. Albert Fink, Chief Engineer, and F. W. Vaughan, Principal Assistant Engineer.

Estimated cost \$1,600,000, including land and depots.

Safety-Catch for Double Hoists or Inclined Planes.—In the report of the Resident Secretary, at the last meeting of the Institute, was included among other things a description, illustrated by a working model, of the improved safety-catch for double hoists or inclined planes, devised and constructed by Mr. J. V. Merrick. The important feature involved in this apparatus, (as also in that device by the same gentleman, formerly described by us in this Journal, Vol. LVI., page 74,) is that the catch is not operated by a spring or other source of motion which is normally at rest, and likely to become useless without giving any sign of such deterioration, but is thrown into action by what may be called a counter-weight which moves with the rest of the apparatus, and cannot in any way be disarranged without immediate notice and indeed stoppage of the machine, in a secure position. In the present case, each cage or car of the double hoist acts as a counter-weight for the catch of the other.

The catches of the two cars are in fact united by a slack cord passed over pulleys near the hoisting-drum or wheel, and so, if the main rope breaks, the cars beginning to run down, the slack cord is tightened with double their velocity, and the catches instantly engaged. By means of the model, repeated demonstration was made of the efficiency of this arrangement.

Paper Belting.—There was also exhibited at the above meeting a specimen of paper belting, manufactured by Messrs. Crane Bros.,

Westfield, Mass. The new article of belting is made of pure linen stock. Equal durability and driving power with leather belting is guaranteed, except when used for shifted belts; none are made narrower than five inches. It does not stretch, nor change shape, and can be made in one piece, of any desired length and width and thickness, and is uniform in every particular. It hugs the surface of the pulleys closely; generates no electricity while running; is sufficiently flexible to pass over six-inch pulleys without cracking; is not injured by the heat, dust, oil or moisture, incident to ordinary use, and is forty per cent. cheaper than leather.

East River Bridge.—At page 149 of our last number, appears a notice of this work, in which is given a list of consulting engineers: among these is a Mr. Lathrop; this is a typographical or reporter's error in the paper from which this notice was taken; the gentleman whose name should have occupied this place being Mr. Benjamin H. Latrobe, of Baltimore.

Ship Canal between New York and Newark.—A meeting of the company recently organized for the purpose of constructing a ship canal between Newark and New York is to be held in a few days in the city of Newark, to elect a board of directors, \$250,000 worth of stock having been subscribed. The capital stock was primarily fixed at \$1,000,000, in shares of \$50 each; but it was enacted, in 1868, that it might be lawful for the Canal Company to extend their canal from Newark Bay across the marshes to a suitable point in Newark City, and to increase their capital stock to such an amount as should be necessary to carry out the original scheme with the extension, the capital is now fixed at \$6,000,000.

The line will run from Dawson street, Newark, extending to Oyster Island, in New York Bay. Thus the line will be almost parallel to that of the Newark and New York Railroad, which is an air line. The total length of the canal will be nine miles. It will be 200 feet wide, as far as the east side of Newark Bay, where it has an increased width of 100 feet, making it at least 300 feet wide at Bergen's Neck. There will be a line of docks on both sides of the canal 200 feet wide, extending the whole length. In Newark there will be piers 300 feet wide, the depth of water being at low tide 16 feet, and 22 feet at high tide, but at the Passaic Channel bank, the depth is only $5\frac{1}{2}$ feet at low tide.

There are difficulties to be overcome in this undertaking, the principal one being that of securing the proper depth of water

in the canal at low tide. The cutting will be the deepest at Bergen Neck, where it is to be 45 feet. The earth from this cutting will be removed to fill up the piers in New York Bay, and these piers, it is said, will be better adapted for commercial purposes than those on the eastern shores. It is intended to run a ferry on the canal between Newark and New York, the distance to be run in 40 minutes.

—*Evening Telegraph.*

Elastic Steel Washer, manufactured by William Wharton, Jr., Thirty-second and Walnut Streets, Philadelphia.

This article, just invented and patented, is intended to meet the obvious need of a complete check on the loosening of screw-bolts and similar fastenings subject to severe, unequal strains. It is a *spheroidal steel washer* of varying diameters, from one and a-half to twenty inches, adapted specially to railroad joints, cars, bridges, and locomotives.

The principle of its effectiveness consists in applying sufficient elasticity to meet the elongation of the bolt consequent upon the unequal strain inseparable from the passage of railroad trains at a high speed, this inequality being owing to the *impaired rotundity of the wheel* which is sure to follow either from imperfection in the original casting, or from the sliding of the wheel under the action of the brake. Observant engineers have long been aware of this grave difficulty, it having been ascertained that when a wheel is injured in its periphery, its action on the rail is entirely changed, the flattened part operating immediately as a hammer, and its murderous jar spreading injury and danger in various directions.

The spheroidal shape of this washer ensures the most economical application of power from a given amount of metal under the circumstances of the case, and its diameter and thickness can be exactly adapted to the size of the bolt and the amount of strain to be encountered.

On the New Method of Purifying Oils, invented by M. Michaud, of Honfleur; the report is from the hand of M. A. Chevalier. After having reviewed the different processes in use from the middle of last century, to render fatty oils, such as rape seed and colza oils, more suitable for use in lamps of a more complicated construction, the author of the report states that M. Michaud's process consists of a defecation of the raw oil by the simultaneous introduction therein of jets of air and thin streams of sulphuric acid, whereby those substances contained in the raw oil, which are injurious

to its properties for use in moderator and carcel lamps are coagulated and brought to the surface of the oil as a scum, which can be easily removed; the oil is next washed with water, afterwards heated by steam to 100° C., and, lastly, filtered through cotton and a layer of clean and pulverized marble, at a temperature of 40° C., yielding an excellent material for use in lamps.

New Marking Ink for Linen.—M. Kuhr recommends the following preparation:—One part of hypophosphite of soda, and two parts of gum arabic, are dissolved in sixteen parts of distilled water. The tissue, linen or cotton, to be marked is thoroughly moistened with this liquid and then left to dry. After having become well dried, the following liquid, composed of one part of nitrate of silver, and six parts of gum dissolved in six parts of distilled water, is used as marking ink, with a quill-pen. The mixtures here described are stated to yield an indelible and very deep black-colored ink.

Artificial Ebony.—This material is prepared on the large scale in the following manner:—60 parts of charcoal, obtained from seaweeds, and previously treated with dilute sulphuric acid, and dried, are ground to powder, and mixed with two parts of liquid glue, 5 of gutta-percha, and $2\frac{1}{2}$ of caoutchouc, care having been taken to mix the two latter substances with coal-tar oil, and thus to render them gelatinous; next 10 parts of coal-tar, 5 of pulverized sulphur, 2 of pulverized alum, and 5 of powdered resin are added, and the mixture heated to 300° F. After having been cooled, a substance is obtained, which in every respect is equal to genuine ebony wood, but is far less expensive, and takes a finer polish.

ECLIPSE NOTES.—Photographs of the Chromosphere.—In a letter just received from Dr. B. A. Gould, we find the following interesting paragraphs which, with his permission, we extract:—“An examination of the beautiful photographs made at Burlington and Ottumwa, by the sections of your party in charge of Professors Mayer and Himes, and a comparison of them with my sketches of the corona, have led me to the conviction that the radiance around the moon, in the pictures made during totality, is not the corona at all, but is actually the image of what Lockyer has called the chromosphere.

“This interesting fact is indicated by many different considerations. The directions of maximum radiance do not coincide with those of the great beams of the corona; they remained constant while the

latter were variable; there is a diameter, approximately corresponding to the solar axis, near the extremities of which the radiance upon the photographs is a minimum, whereas the coronal beams in these directions were especially marked during a great part of the total obscuration. The coronal beams stood in no apparent relation to the protuberances, whereas the aureole, seen upon the photographs, is most marked in their immediate vicinity. Indeed, the great protuberance, at 230° to 245° , seems to have formed a southern limit to the radiance on the western side, while a sharp northern limit is seen on all the photographs at about 350° , the intermediate arc being thickly studded with protuberances, which the moon displayed at the close of totality. The exquisite masses of flocculent light on the following limb are upon the two sides of that curious prominence at 93° , which at first resembled an ear of corn, as you have said, but which in the later pictures, after it had been more occulted, and its southern branch thus rendered more conspicuous, was like a pair of antelope horns, to which some observers compared it. Whatever of this aureole is shown upon the photographs, was occulted or displayed by the lunar motion, precisely as the protuberances were. The variations in the form of the corona on the other hand, did not seem to be dependent in any degree upon the moon's motion.

"The singular and elegant structural indications, in the special aggregations of light on the eastern side, may be of high value in guiding to a farther knowledge of the chromosphere. They are manifest in all the photographs by your parties which I have seen, but are especially marked in those of shortest exposure, such as the first one at Ottumwa. In some of the later views they may be detected on the other side of the sun, though less distinct. But the very irregular and jagged outline of the chromosphere, as described by Janssen and Lockyer, is exhibited in perfection.

"This happy result is clearly attributable to the relative shortness of the time of exposure by which the highly photographic rays of the chromosphere have depicted themselves, without obliteration by the mass of coronal light which veiled them from the eye. Let us hope that at the next total eclipse some impressions may be taken with an exposure not exceeding a single second, as you have suggested on p. 210. The inference seems warrantable that in this way, better than in any other, the internal structure of the protu-

berances may be exhibited though other phenomena may fail to record themselves.

"You will observe that some of the brighter, petal-like, flocculi of light have produced apparent indentations in the moon's limb at their base, like those at the bases of the protuberances. These indentations are evidently due to specular reflection from the moon's surface, as I stated to the American Association at Salem, last month. Had any doubt existed in my mind, previously, it would have been removed by an inspection of the photographs.

"I shall send the substance of these remarks to Prof. Coffin, as a sort of postscript to my report, which contains only the results of personal observation at the time."

Abstract of Prof. Young's Report.—The observer was a member of the party under the direction of Prof. J. H. C. Coffin, of the *Nautical Almanac Office*, stationed at Burlington, Iowa.

The instrument employed was a spectroscope with 5 prisms of 45° each, having faces $2\frac{1}{4}$ by $3\frac{1}{4}$ inches; the collimator and telescope had apertures of $2\frac{1}{4}$ inches, with a focal length of 17. These were connected with a "comet seeker" of 4 in. aperture and 30 in. focus, used with an eye-piece, and giving an image of the sun, $2\frac{1}{4}$ inches in diameter, on the slit of the spectroscope. A graduated screen at the slit determined positions of points on the sun's limb, and a wire micrometer measured the positions of spectrum lines. The whole was mounted equatorially with slow motion screws.

Protuberances were noted before the eclipse at $+85^\circ$ to 100° , large and not very bright; at $+146^\circ$, small and bright. The photographs show another at 155° , which escaped notice; also at -70° to 80° low, but pretty bright; and at -130° , very large and bright, the principal one. Angles are reckoned on the sun's limb from the North point, + towards the East, — towards the West.

The first contact was observed by watching the gradual shortening and final extinction of the *bright line*, c, in the spectrum of the prominence, which happened to be at the point of contact. The moon's approach was perceived full thirty seconds before its actual appulse; the observation was perfectly easy, and the time determined is certainly to be relied on within half a second, and probably much less. The presence of a prominence at the point of contact is not essential to the success of the method, as there is

everywhere on the sun's limb sufficient depth of chromosphere to answer the purpose.

It is proposed to apply the spectroscope to observations both of the external and internal contacts at the next transit of Venus.

During the totality, the following 9 bright lines were observed in the spectrum, viz: c dazzling in brilliance; 1017.5 (near D, the numbers refer to Kirchhoff's scale,) very bright, but not equal to c; 1250 ± 20 , very faint, position only estimated; 1350 ± 20 , like the preceding; 1474 (a little below E,) conspicuous, but not more than half as bright as 1017.5; F, next to c in brightness; 2602 ± 2 , a little fainter than 1474, position determined by micrometrical reference to the next; 2796, a little below G, the well-known H γ line in brightness between 1017.5 and 1474; and finally H, or H δ , somewhat brighter than 1474. B was not seen, it is supposed, on account of a mistake in carrying that portion of the spectrum through the field while there was no prominence on the slit.

* The line 1474 was recognized as belonging to the *spectrum of corona*, in the first place, by its extending clear across the spectrum, while 1017 did not, and then by its remaining visible when the slit was moved away from the protuberance, while the other lines (c and 1017) disappeared. The impression of the observer is that faint lines 1250 and 1350 behaved in the same manner, but his recollection as to this point is not very certain.

These three lines, 1250, 1350 and 1474, coincide far within the probable errors of observation with three lines observed by Prof. Winlock in the spectrum of the Aurora Borealis. The two first are not accurately enough determined, in position, to allow much stress to be put upon any apparent coincidences on their part, but

* A careful examination of the photographs of the prominences on the eastern limb of the sun, upon which the slit of the spectroscope was directed during the first half of totality, somewhat diminishes my confidence in the conclusion of the text, as to the nature of these 3 lines. I think it absolutely certain that they do not belong to the spectrum of the *brilliant portion* of the prominences; but the photograph shows, in addition, an extensive nebulosity surrounding the nuclei, with a pretty definite boundary of its own. This nebulosity is best seen in No. 2 of the totality pictures taken at Burlington. Now, it is *possible* that these lines may belong to this *nebulosity*, and not to the *corona proper*; for I cannot recall, with certainty, whether the 1474 line retained its brilliance at any considerable distance from the prominences. My impression is that it did, and that the text is correct, but do not wish to be too positive. The eclipse of December, 1870, will decide, of course.

the last is perfectly well known, and its exact agreement, throughout with one of the fainter lines of the Aurora, when combined with the general appearance of the Corona and other considerations, give a good deal of probability to the conjecture that *our Aurora Borealis and the Solar Corona are identical phenomena.*

The line 1474 is given by both Kirchhoff and Angström (not by Huggins, who, however, omits many faint lines,) as belonging to the *iron* spectrum, and this suggests the inquiry whether we are to admit the existence of *iron* in the auroral heights of our atmosphere, or are to account for this line in the iron spectrum by some unknown substance of gaseous nature.

The corona showed, also, a faint continuous spectrum without *any trace of dark lines.* The light of this faint spectrum, tested by a tourmaline held in the hand next the eye, was strongly polarized in a plane passing through the sun's centre. As the direction of the spectroscope slit was nearly radial, it is not impossible that Prof. Pickering may be right in explaining this polarization as caused by the successive refractions through the prisms.

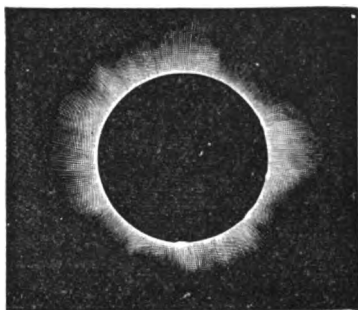
[The two preceding communications from Dr. Gould and Prof. Young, sent to us independently, show a remarkable coincidence in their results which cannot but point to an important fact. To put this into a few words it would seem likely that Prof. Young has observed the spectrum of that diffused chromospheric matter of which Dr. Gould has found the photographic record on the pictures made by the Philadelphia expedition. If reference is had to Plate II. facing p. 265, in Prof. Mayer's Report, in this number, Dr. Gould's description of the location of the glow on the photographs can be readily followed.—ED.]

Prof. Young's Determination of First Contact.—In our notice of this subject in our last issue, page 149, we omitted to notice that Prof. Young finds that the presence of a prominence at the point of first contact, though facilitating the process, is not essential to his method, since the spectrum of the chromosphere is quite enough for the same purpose.

In quoting from his letter on page 213, we also may have given too strong an impressiveness to his suggestion that the corona lines were identical with those of iron. His intention was to notice their apparent approximation merely.

The Corona and its Photographs.—It is a very fortunate thing that the numerous parties by whom photographs were made

of the late eclipse, in hardly any two instances followed the same plan of arrangement or aimed at the same class of results. Thus, while the Philadelphia Expedition, in pursuance of Prof. Coffin's suggestions, made their preparations with the view of obtaining such "accurate and well-defined pictures as might be the basis of astronomical calculations." In this they have unquestionably succeeded beyond all others, as we hear from all sides, now that pictures have been distributed and compared.



Their views of lunar mountains, sun-spots, faculæ, chromosphere, and crepuscule being unapproached, and their views of the solar prominences only rivalled by one obtained by Dr. Curtis.

The party under Prof. Pierce, consisting, photographically, of Mr. Whipple, of Boston, (who, with Mr. Black and the late Prof. Bond, of Cambridge, made, in 1850, the first celestial photograph,) addressed themselves exclusively to the recording of that strange phenomenon, the corona. To secure any impression from this object, which, notwithstanding its apparent brightness is remarkably deficient in photographic power, it was necessary to make a very small image, and to give a very long exposure.

The telescope was therefore arranged to produce an image in its principal focus simply, and during the totality an exposure of 40 seconds was given. By this means a picture was obtained of which the accompanying cut is a very careful copy. From the long exposure and motion of the moon, as also, probably, of the light in the corona, there is little sharpness of definition, and the prominences only appear as bright spots. The general shape of the corona is, however, very well given, and the curious appearance of curvature, in some parts, is very manifest. This and other pictures—if others than the one we have seen were made—may throw some light upon this extraordinary object.

Moon Pictures.—There are few objects which are more difficult to portray, with accuracy, than the surface of our satellite. The combination of shadows, with tints produced by difference of material, the absence of strongly marked and conspicuous features to serve as starting-points for measurement, and the extreme minute-

ness and delicacy of markings and tint graduations, have combined to defy the skill of the artist and the engraver. This is especially evident since the successful application of photography has furnished us with such admirable standards for comparison.

In the *Quarterly Journal of Science* for July, 1864, appeared an admirable lithograph of a small region to the S. E. of Tycho, which left all previous attempts far in the rear, and, indeed, for the very limited area concerned, left also little to be desired. This was copied in an excellent wood-cut in the beautifully illustrated work of Guillemin, *La Ciel*, and also as a mezzotint, in a small volume by the same author, entitled *La Lune*; but the large picture of the full moon, given in the same volume, is a mere caricature of the lunar countenance. Two much better pictures have appeared in one of the latest numbers of Louis Figuier's *Merveilles de la Science*. A curious etched daguerreotype by De la Rue was published some years ago in the *Monthly Notices* of the Royal Astronomical Society. This picture is curious as an etched daguerreotype, but of little value as a likeness of the moon, giving only a few prominent points with distinctness. In Vol. LVI., p. 136 of this *Journal*, we published a large lithograph which, by insertion of names and numbers, was made into a map, and this was acknowledged, by the most competent judges, to be the best moon picture produced up to that time.

We now, however, give our readers an engraving that, for artistic beauty and delicate finish, excells even this, though on account of its smaller size, and the nature of the full phase, it is not available as a map, or useful for topographical study, as was the other.

This picture was engraved by Messrs. Van Ingen & Snyder, under our inspection, from one of Mr. Rutherford's photographs for Prof. S. H. Peabody, to illustrate his work entitled *The Elements of Astronomy*, now in course of publication. This is, beyond doubt, the best engraving of its kind ever published, and reflects great credit on the artists who have produced it. If the other illustrations in Prof. Peabody's book equal this one, it will be without a rival in this respect, either in this country or in Europe.

Very extensive atlases of the moon are announced as partly published by the British Astronomical Association, but these we have been unable to find, and the descriptions which we have seen indicate that they are mere charts and not pictures.



Engraved by Messrs. Van Ingen & Snyder from a Photograph by Mr. L. M. Rutherford.

Editorial Correspondence.

THE USE OF CORNISH ENGINES FOR THE WATER SUPPLY OF CITIES.

MR. EDITOR:—The Cornish Engine, when well regulated and in full operation, presents a most imposing exhibition of the power of steam, and of its control by human ingenuity. Especially is this the case when its work is the elevation of water for the supply of cities and towns, because the entire mechanism is visible at the same time, the pump being situated within the engine house. The observer sees the ponderous plunger tossed upwards, at first with great velocity, gradually coming to rest at the topmost point of its stroke, then descending quietly to the lowest point, always arrested at the same positions, within a short distance of the buffers, apparently without any adequate agency.

Several requisites are, however, combined to produce this result; a failure in either of which will impair the efficiency of the machine, and may, without warning, produce disaster. These conditions are, uniformity in the steam and vacuum pressures, constant frictional resistances in the machine itself, and a steady pump resistance.

The two first named are generally attainable with proper valve-gearing and proper care. The latter condition, in mining engines, is comparatively easy of attainment, because the work is distributed over a series of lifts, and if accident occurs in any one lift by the holding up or breakage of a valve, or otherwise, a fraction of the resistance only is removed. But when this engine is used to drive one pump only, as is customary in water works, such an accident may remove all pump resistance, and serious injury is likely to result.

To avoid this would, I think, be easy (and without great complication,) by the introduction of additional inlet and outlet valves, to be made of or faced with rubber, which valves should be placed respectively below the main inlet and above the main outlet valves of the pump. These supplementary valves should be of larger area of passage than the main valves, and so long as the latter were in action would be subjected to no strain, while they would operate noiselessly, and without creating much additional friction. They

would, therefore, wear very little, and in case of accident to the main valves, would prevent the reflux of the column of water, and would, consequently, maintain the constant pump resistance through the stroke. During the next stroke, in case the difficulty had occurred from chips or dirt, these obstructions to closing would be washed out.

In some of the English water works engines, the same end has been sought by the use of seats carrying several disc or ball-valves, one or more of which may hold up without producing accident. Some engineers, however, prefer metal valves of two, three, or four "beats," and in such cases the expedient alluded to would be applicable, and would operate with greater certainty. In one case in this country, (Buffalo, N. Y.,) the supplementary outlet was employed for another purpose, and with good effect. But it is apparent that accident is more likely to occur to the inlet-valve, and, when it occurs, to break down the engine.

By the expedient referred to, the only serious objection to the use of the Cornish Engine for the purpose named is removed; and as its expense would be comparatively small, the investment would be good, as absolutely preventing that class of accidents which are most common and troublesome.

It is indisputable (on any substantial grounds) that, in point of economy of fuel, the Cornish Engine for pumping water, when properly made, is preëminent. It alone combines the two essentials for such economy, viz: A sufficient mass of moving material to enable steam to be used at high grades of expansion, and a velocity of movement in the water column, dependent solely upon the inertia of that column. The best effect from expanding steam cannot be obtained without the mass of material in which to store the surplus power at first and give it up at subsequent stages of its movement after the steam is shut off. The best result upon the water cannot be obtained, unless this mass of material, when pumping, can accommodate its velocity to that of the water column urged by it.

The various forms of "duplex" or "twin" engines, where the stroke of one piston is limited and reversed by the other piston then moving at its highest speed, are deficient in the first requisite named; and although this defect may be partially overcome by using combined cylinders, it cannot be entirely removed, except at great expense. This class of machines, however, being double-

acting, are deficient, to an important extent, in the second requisite I have named, viz: in accommodating their movement to the normal velocity of the water column.

There are forms of crank engines, in which, by the use of fly-wheels, a proper momentum may be obtained to absorb and give out the surplus steam pressure; but this class of machines are all deficient in their accommodation of speed to that of the water column.

It is evident, from these considerations, that the "Cornish" is, theoretically, the best pumping engine. Practically, it is also the best, if properly made, and with efficient safeguards against accident.

It is easy of management, liable to the least possible amount of wear, and is at least not more expensive in first cost than other forms. And, with the safeguards pointed out in this article, added to others which have been suggested by experience, it would be more free from liability to derangement.

J. VAUGHAN MERRICK.

Philadelphia, Sept. 8th, 1869.

WATER POWER ON DAMS BUILT TO IMPROVE RIVERS FOR CANAL FEEDERS, &c., WHERE A UNIFORM DEPTH OF WATER IS REQUIRED.

MR. EDITOR:—The use of water power on the State dams, in the State of New York, built for the purposes of navigation, was formerly leased to the highest bidder, subject to the control of the Superintendent of Canals. The lessee was allowed to cut into the dam for a flume, from which the water could be used on all the various wheels in use. But it was soon found impossible to control water enough, in a dry time, for the purposes of navigation. The leakage of gates, bulkheads and flumes, and the clandestine use of the water, after the Superintendent had forbidden it, as provided by the lease, was so great that it was impossible to keep a uniform depth of water in the canals. Therefore, the Legislature abolished the leasing of water power on any of the State dams, which deprives the State, as well as the people, of more than half the usefulness of such dams, as water power is nowhere so useful as when situated on navigable waters, which afford the best facilities for transporting the raw materials required by the machinery as well as the produce

from them, adding largely to the tolls on and usefulness of the navigation.

Such is the necessity of the following plan for using the water without cutting into the dam at all, avoiding the possibility of drawing down the water below the top, using only the water as it falls over the dam, and would otherwise go to waste. This plan has no flume, bulkhead or gates. The navigation is first supplied, the waste is then utilized by machinery, which usually amounts to much more than is used for navigation.

Fig. 1 represents the water in use. Fig. 2 represents the water shut off from the wheel and passing off over the apron, with the same freedom as when in use. All of the machinery, both for working the apron or gate, and the mill, is situated under the apron. The upright shaft, which conveys the power to the mill, stands below the abutment of the dam out of the water passage, and connects, by bevel cog-wheels, with the extended water-wheel shaft.

Fig. 1.

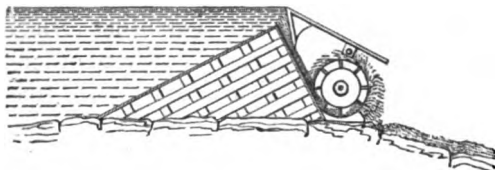
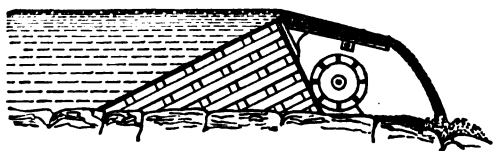


Fig. 2.



There is not the slightest obstruction to the passage of the water, whether in use or not; nor can the surface be drawn down any lower than it would be if no mill was there, thus doing away with every possible objection to the use of a large amount of waste water power, situated where it is most wanted for the benefit of the canals as well as the people.

This method, in other cases, wherever there is no object in preventing the water, when not in use, from passing off, will be found very economical and efficient in the use of water power for many purposes, as it does away with all expense of flumes, bulkheads, spouts, &c.

Lyons Falls, N. Y., 7th Sept., 1869.

D. S. HOWARD, C. E.

Civil and Mechanical Engineering.

ON THE CONSTRUCTION OF DAMS AND THE IMPORTANCE OF THEIR PERMANENCE.

By D. S. HOWARD, C. E.

THERE are few persons engaged in the building of dams who realize the importance of making them permanent, particularly at or near the head waters of streams. The cost of such dams is but a trifle, compared to the consequences of their failure, in times of unusual floods, the only time when what is called a well built dam will fail. Therefore the better a dam is built, if the work be not planned and executed so as to be permanent under all circumstances, the greater the curse it is to the community below, all the way to the mouth of the stream.

There can be no excuse for the failure of a dam, unless we give up the superiority of the human intellect over inanimate matter. An engineer who does not understand the laws that govern the action of water, or has not conscience enough to create a care for his fellow-creatures, sufficient to build a permanent dam, should not be allowed to erect any structure of the kind on any stream, situated above any other property, liable to damage by the failure of such structure.

Most of the immense damage done by the recent freshets throughout the Northern States, has been due to the failure of dams at or near the heads of streams. The one at the outlet of North Lake, near the head waters of Black River, built by the State of New York for a reservoir, to supply the Black River Canal and Erie Canal Feeder, was one of this description.

The dam was 30 feet high, built across the outlet of a small lake of about 450 acres surface, and was constructed wholly of earth, except a longitudinal course of sheet piling perpendicularly through the centre, with a course of concrete on the upper side of the sheet piling, and a spilling way of wood, in the shape of a shoot, forty feet wide and seven and a half feet deep, on the lower side of the dam; four feet of the seven and a half had been permanently planked up, since the completion of the dam, which is said by Mr. Whittlesey, the builder, to be the cause of the failure.

The next dam below was built by the State across the Black River, to turn the water into the canal feeder. The spilling way to this dam was about twelve feet high, and one hundred feet long, with an upper slope of two to one, on a rock foundation, between two short, square stone abutments, with earth-works each way to high land.

The first of these dams was destroyed altogether by the recent freshet. The second was left entirely bare of earth-work on one side, leaving nothing but the stone and wood-work, which stood perfectly erect in the middle of the torrent, which shows conclusively, that if the whole had been as well planned, there would have been no failure.

Notwithstanding the immense flood thus created, there were numerous dams on the same stream below, that sustained little or no damage. But not so with other structures necessarily situated near them, such as grist-mills, saw-mills, tanneries and other works dependent on them, for the power created for their purposes, together with bridges and dwellings, barns and outhouses, heretofore considered out of reach of any possible flood. It is estimated that more than a million of dollars worth of such property has been swept from their foundations on this river, besides the loss of lives and the distraction of business, which cannot well be estimated in money value.

The Legislature of the State of New York being in session, promptly ordered an estimate of all the damages done by the recent freshet on the Black River, with a view of remunerating the individual pecuniary losses, so far as they can be estimated, by which it becomes a direct national calamity, so far as the remuneration goes, but no person will say, that all the indirect damages will ever be paid by the State, therefore whatever the State does pay, would have been better invested, if it had all been paid to an engineer capable and careful enough to have planned and executed the above works, in accordance with the simple laws which govern the action of water, thereby saving a large amount to individuals, (as well as some human life,) which is no less a loss to the state, for whatever is a loss to an individual in the State, and a gain to no other similar individual, is as much a State loss, as it would have been if the individual had been remunerated by the State.

One of the most apparent causes of the failure of earth-works at the ends of dams, is the short angular form, usually adopted, of the

the lower side of the abutments, which causes a strong eddy below, calculated to undermine the bank adjoining, which is soon so much weakened as to be carried away by the pressure of water above. This observation was observed at the height of the recent freshet, to be going on at the north end of the State dam at Lyons Falls, and, although the abutment was built into the natural bank, it was so far affected by the eddy, caused by the form of the abutment, that the bank began to cave, and cracks high up on the bank indicated that if the freshet had continued at its height a few days longer, the whole river would have passed around the north abutment of the dam; adding still another swell, to the disastrous effects of ignorance and carelessness, already created.

Another frequent cause of failure in earth-works of dams, dykes and canal banks is an improper disposition of the material of which they are constructed. If the finer material be placed in the lower side of the embankment, it will prevent the leakage from passing off, and cause the whole embankment to become saturated, rendering it very liable to float away. Whereas if the fine material be placed in the upper side of the embankment, the coarser, with its greater weight, stands with greater firmness as a support to that which stops the water, and by more readily letting off the water that may permeate the finer material, leaves more weight in the embankment to resist the pressure of water. Too much care cannot be taken in selecting the finest impervious material, for the upper side surface of an embankment for stopping water. This done, the remainder of the material should be gradually coarser towards the lower side, which, if convenient, should be a course of stone. A dyke or embankment, properly built on this principle, with six feet top surface, with slopes of one and a half to one, may be extended to any height, and sustain a pressure of water within one foot of the upper surface, with perfect safety.

But if the material be so disposed as to permit the water to saturate the embankment without passing off, the weight of the embankment will be diminished, to the extent of the weight of water contained in it.

The spilling way to dams, if on a rock foundation, may be constructed perpendicular on the lower side, with a water-tight upper slope of two to one, and be perfectly safe without bolting to the rock, whether it be built of stone or wood, if the lower side be open to offer a free passage for the water that may pass through the

upper slope. But if on a foundation of loose stone or gravel, which is sometimes unavoidable, there must also be a water-tight slope on the lower side of about one to one, down to a horizontal water-tight apron, about eight feet wide, sunk below the bed of the stream. If the apron be above the bed of the stream, it will be liable to be undermined by a verticle eddy, formed by the horizontal force of the water leaving the apron, acting on the dead water immediately below the surface, on the lower side of the apron.

On some foundations where the water is to be raised very high, it will be necessary to dig a puddle ditch at the foot of the upper slope, six feet wide, and as deep as the nature of the material requires, in which sheet piling should be driven as deep as possible, and the upper ends well fastened to the bed timbers of the upper slope. Then fill the ditch above the sheet piling with clay and gravel about half and half, well puddled in, to about four feet in height above the foot of the slope, and extending up on the slope one-third of the way to the top, where a timber one foot square, should be bolted, from one abutment to the other, to prevent the current, in great freshets, from carrying the gravel over the dam.

It is impossible to reduce the building of dams to perfect science, but the laws which govern the action of a perfect fluid, are known to be in accordance with exact science, and must be understood by the constructor of dams to ensure success, as water is so near a perfect fluid, their strict observance will in all cases be required for its control.

The hydraulic engineer must not only know the weight of water, the static pressure and dynamic force, but the effects of various forms of resistance with which it may meet. He must also understand the laws relating to the conditions of the various materials upon which dams are to be built, the simplest of which is solid rock, hard pan, &c. Most other materials partake, in some degree, of the nature of fluids, according to the degree of friction between the particles, or the power required to put them in motion.

The pressure of water being equal in every direction, according to the weight and perpendicular height, loose materials in foundations of very high dams, if allowed to become saturated, will assume the character of a fluid sufficiently to be pressed out from under the superstructure, by the weight of water above, causing an upward pressure below. Hence the necessity of sheet piling and concrete or puddling above, to cut off all communication as

much as possible, between the water in the pond above and the material beneath the dam, or to such an extent as to prevent the water from entering the foundation, faster than it can pass off, without moving the material with it.

The great importance of permanence in dams is only realized by those interested in water power, whose works must necessarily be as near the water as the highest natural freshets will permit. It is possible to convey water power to situations where it may be used in perfect safety from any flood, by various mechanical contrivances; but not without a sacrifice of power, and expense of construction and repairs, which would far exceed the extra expense of building permanent dams, on any important stream.

While we have laws against nuisances, and many comparatively useless laws, it would seem expedient to have, in addition to the laws against flowing land above dams, to have some against flooding lands and other property below. In answer to this it may be said that common law is sufficient to collect damages in case of carelessness of all kinds; but a man may be able to build a worthless dam, and jeopardize a large amount of property below without being able to pay any part of the damage that may be done by the destruction of his own. Therefore it would seem to be a salutary precaution, if he could have been obliged to give bail for the damages that might be done by a failure of his dam. Truly the world is governed too much, but evidently not too wisely.

Lyons Falls, August, 1869.

BELTING FACTS AND FIGURES.

By J. H. COOPER.

(Continued from page 163.)

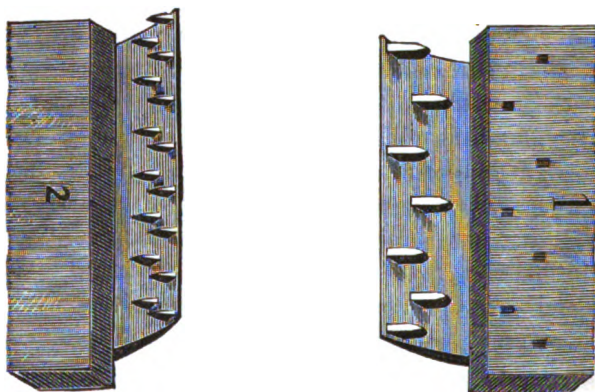
Wilson's Patent Belt Hooks.

WE are indebted to Crane Bros., Westfield, Mass., for description and illustration of the above, which we present herewith.

No. 1.—The teeth go through the belt and clinch. To be used only on belts running at very high speed over small pullies, and in making up belts, instead of lapping, glueing and pegging.

No. 2.—Is the only belt hook in the market that can be used repeatedly and successfully more than once. A hammer is all that is required to secure them to belts. Lay the hook down on some-

thing solid, with the teeth up, and *drive the belt down tight* to the plate. None of the belt is cut away by punching holes. The strain comes in *fifteen* places instead of *three*, as with lacings. Belts can be mended in one-quarter the time required for any other hook or lacing. They will last longer than a dozen lacings. They are the *only good* fastening for rubber or paper belts.



Wilson's Patent Belt Hooks, December 15, 1869.

These hooks have been thoroughly tried for three years, in all places, in machine shops, cotton, woolen and paper mills, and all who use them admit that they are the *best* and *cheapest* fastening in use, taking into account the *durability* of the hooks, *wear* and *tear*, and *time* in *mending* belts.

The Messrs. Hoyt Bros., of New York, present a patent belt fastening in the form of a double shanked rivet with a link or elongated washer having a perforation at each end for receiving the end of each rivet.

These rivets are used for making butt as well as lap joints in belts; in either case the belt is punched as for lacing, with holes equidistant from the joint. The perforation, of course, being of such size and distance asunder as to just allow the double rivet to pass tightly in when the whole is secured by laying on the link washer and hammering the ends of the rivets into the countersunk holes of the latter, care being taken to embed both head and washer in the substance of the belt, flush with the surfaces, in order that they may not wear by contact with pulleys.

They also have the exclusive right to use a patent "Rivet and Burr." This improvement consists of a conically formed head to the rivet, which gives greater strength of attachment thereto. The

Burr has a form similar to that of the head, and has in addition a central hole countersunk on top for receiving the spread of metal of rivet end when hammered into it. This is the best form of rivet that can be made, as it gives the greatest strength and durability to all the parts, and is easily sunk into the substance of the belt to a level with its surface.

They recommend for round belts a grooved pulley in which the section of groove shall be neither triangular nor semicircular, but rather that of a spherical triangle or gothic arch.

This form undoubtedly gives greater belt contact than any other with a given amount of tension on belt.

They also urge the importance of covering pulleys with leather, "fifty per cent. more work can be done by machines without belts slipping if so covered." "The covering of pulleys with leather, in many establishments where there is a deficiency of power, would produce such an improvement as to astonish those not acquainted with its value."

"Large pulleys and drums may be covered by narrow strips of leather, wound around spirally, but narrow pulleys should be covered by leather of same width as pulley face."

"One pulley covering is cut into strips of required width cemented and made of even thickness, by a machine, then wound in coils like belting."

Errata.—On page 107, 8th line, 888-88 should be 88-888.

On pages 108 and 109 the paragraph commencing :—"Where pulleys," &c., and "The intermediate pulley," &c., should be credited to *Engineering* for Jan. 22d, 1869.

On page 109 the paragraph commencing "A leather belt," &c., should be credited to Jas. B. Francis, C. E., in *Frank. Inst. Jour.* for May 1866, page 843.

(To be continued.)

THE HYDRAULIC SWING BRIDGE OVER THE OUSE.

BY SIR WILLIAM ARMSTRONG.

THE formation of the Hull and Doncaster section of the North-eastern Railway necessitated the crossing of the River Ouse by an opening bridge, so as to admit the passage of the important traffic carried on in large sailing-vessels. It was also necessary that there should be not more than one pier in the navigable channel, with a clear opening of not less than 100 feet on each side. The requisites of the railway and river traffic necessitated a construction that ad-

mitted of being opened and closed very rapidly. It was also necessary that the power applied should be capable of controlling with great accuracy the momentum of so ponderous a mass, and hydraulic power, being so eminently qualified for this purpose, was therefore selected as the agent. The instances in which hydraulic power had been previously applied to the opening and closing of movable bridges are very numerous, amounting to upwards of fifty examples. Most of these bridges have been erected for the passage of railway traffic, both on main lines and branches, and they may be divided into three classes. 1st. Swing bridges on which the bridge is lifted from its solid bearings by a central press previously to being turned by hydraulic pressure. 2d. Swing bridges on which the bridge rests upon a circle of two rollers, and is turned by water pressure without being lifted. 3d. Draw bridges on which the movable platform is drawn back and pushed forward in the line of the roadway by means of hydraulic machinery. In addition to the hydraulic bridges comprised in these three classes, there is one example of a bridge on the bascule plan being worked by hydraulic power. This is at Liverpool, over one of the dock entrances. The first hydraulic swing bridge was erected in 1852, over the River Severn, on the Gloucester and Dean Forest Railway, and the first hydraulic drawbridge was erected in 1853, over the River Tovey, on the South Wales Railway, near Carmarthen. All the swing bridges which turn on a centre pier, and span an opening on each side, have been made to turn on live rollers without being lifted; because, in bridges of that construction, neither extremity can have any steadying support in the act of turning, but in some instances a central press has been applied to relieve the rollers of part of the weight. Where single-leaf swing bridges are lifted by a central press, the deflection is taken off by letting down the bridge upon its solid bearings when closed; but in the case of drawbridges and swing bridges not lifted by a central press, hydraulic machinery is applied to lift the overhanging end or ends so as to take off the deflection after closing. The openings crossed by these various forms of bridges have varied from 30 to 100 feet span. The heaviest bridge to which the central lifting arrangement has been applied is one over the Regent's Canal, near the London Docks, in which instance the weight lifted and turned amounts to 450 tons. In bridges with the central press, the head of the lifting ram fits into an inverted cup upon the bridge to allow of oscillating movement,

and the bridge in swinging turns upon the water by carrying the ram round with it. The pressure of water employed in the central hydraulic press is about 800 pounds per square inch, and in the largest of these bridges the diameter of the ram turning upon the water is 51 inches. In most cases the bridges are in connection with a system of hydraulic pressure applied to cranes and other machines in the vicinity, the pressure being supplied in the usual manner by steam engines pumping into accumulators. But in some few instances where there is not such a supply of power at hand, the pressure is supplied by hand pumps charging the accumulator, and thus storing up the power ready for application whenever required. At the Ouse Bridge there was no supply of hydraulic power at hand, and in that instance the total power required was too large to be supplied by hand labor. It was further necessary, on account of the position of the swing bridge, either to convey the power to the centre pier by a pipe under the bed of the river, or to produce it upon the pier by placing a steam engine within the pier itself, and the latter plan was adopted. The total length of the bridge fixed and movable, is 830 feet. The fixed portions consist of five spans of 116 feet, from centre to centre of piers. The bridge being for a double line of railway, each span is composed of three wrought iron girders of the bow-string form, the centre girder having a larger section to adapt it for its greater load. These girders have single webs, and are 9 feet deep in the centre. The total width of the bridge from outside to outside, is 31 feet. Each of the piers for the fixed spans consist of three cast iron cylinders, of 7 feet diameter, and about 90 feet in length. The depth from the under side of the bridge to the bed of the channel, in the deepest part, is about 61 feet. The headway beneath the bridge is 14 feet 6 inches from high water datum, and 30 feet 6 inches from low water. The swinging portion of the bridge consists of three main wrought iron girders, 250 feet length, and 16 feet 6 inches deep at the centre, diminishing to 4 feet deep at the ends. The centre girder is of larger sectional area than the side girders, and, instead of being a single web, is a box girder 2 feet six inches in width, with web-plates 7-16th to 5-16th inches in thickness, and the top and bottom boom contains about 132 square inches of section. The roadway is carried upon transverse wrought iron girders resting upon the bottom flanges of the main girders. In the centre of the bridge the main girders are stayed by three transverse wrought

iron frames securely fixing them together; and over the top of these frames a floor is laid, from which the bridge-man controls the movements of the bridge. An annular box girder, 32 feet mean diameter, is situated below the centre of the bridge, and forms the cap of the centre pier; this girder is 3 feet 2 inches in depth, 3 feet in width, and rests upon the top of six cast iron columns—each 7 feet diameter—which are arranged in a circle, and form the centre pier of the bridge. Each of these columns has a total length of 90 feet, being sunk about 29 feet deep in the bed of the river. A centre column, 7 feet diameter, is securely braced to the other columns by a set of cast iron stays which support the floor of the engine room. This centre column contains the accumulator, and forms the centre pivot for the rotation of the bidge. The weight of the swing bridge is 670 tons. There is no central lifting press, and the entire weight rests upon a circle of conical live rollers. These are 26 in number—3 feet diameter and 14 inch width of tread—and are made of cast iron, hooped with steel, and they run between two circular roller paths 32 feet in diameter. These roller paths are 15 inches, and are made of cast iron, faced with steel; the axles of the rollers are horizontal, and the two roller paths are turned to the same bevel. The turning motion is communicated to the bridge by means of a circular cast iron rack $12\frac{1}{2}$ inches wide on the face, and $6\frac{1}{2}$ inches pitch. It is shrouded to the pitch line, and is bolted to the outer circumference of the upper roller path. It gears with a vertical bevel wheel, which is carried by a steel centre pin, supported on the lower roller path. This is driven by a pinion connected by intermediate gearing with the hydraulic engine. There are two of these engines, duplicates of one another, either of which is sufficient for turning the bridge. The force required to turn the bridge is equal to about ten tons applied at the radius of the roller path. Each hydraulic engine is a three cylinder oscillating engine with simple rams $4\frac{1}{4}$ inches in diameter and 18 inch stroke. These engines work at 40 revolutions per minute, with a pressure of water of 700 pounds per inch, and are estimated at 40 horse power each. The steam engines for supplying the water pressure are also in duplicate, and are double cylinder engines, driving three throw pumps 2·8 in diameter and 5 inch stroke which deliver into the accumulator. The diameter of the steam cylinders is 8 inches, and the stroke of the piston is 10 inches, each engine being 12 horse power. The accumulator consists of $16\frac{1}{2}$ inch ram,

with a 17 feet stroke, and is loaded with a weight of 67 tons, the weight being composed of cast iron segments suspended from a crosshead and working down in the cylindrical casing formed by the centre cylinder. For the purpose of obtaining a perfectly solid roadway when the bridge is in position for the passage of trains, and also for securing the perfect continuity of the line of rails, the following apparatus is applied. Each extremity of the bridge is lifted by a horizontal hydraulic press, acting upon levers forming a toggle joint, the piers having two rams acting in opposite directions upon two toggle joint levers, which act one upon each side of the end of the bridge, and they are connected by a horizontal bar, which is confined by a stud sliding in a vertical guide, so as to ensure parallel action of the two toggle joint levers, and producing exactly parallel lifting of the two sides of the bridge. Three resting blocks, one under each girder, are pushed home when the end of the bridge is lifted, by means of two separate hydraulic cylinders, and the bridge is then let down upon the resting blocks by the withdrawal of the toggle joint levers, and the bridge ends are then perfectly safe for trains to pass over. The hydraulic cylinders for this fixing gear at the two ends of the bridge are worked by the bridge-man from the centre platform by means of two levers, and for the purpose of enabling him to regulate the stopping of the motion of the bridge at the right place an indicator is provided, consisting of a dial upon a pedestal. This dial has two pointers, which are actuated by the motion of the bridge. One of these pointers makes two revolutions, and the other 42 revolutions for one complete rotation of the bridge. These pointers are similar to the hour and minute hands of a watch, the slower pointer being analagous to the hour hand, and the quicker one to the minute hand. The bridge has no stop to its movement, and would swing clear past its right position if the turning power were continued, but the bridge-man being guided by the indicator, knows when to stop and reverse the hydraulic engines, for the purpose of stopping the bridge at its right place. When this is done, a strong bolt, 3 inches thick, in each end of the bridge, pressed outwards by a spiral spring, is shot into a corresponding notch in the fixed girder work, so as to lock the bridge; and when the bridge is required to be opened, these bolts are withdrawn by a wire cord leading to the platform on which the bridge-man is stationed. As the accumulator is stationary, and the fixing gear at the ends of the bridge travels with the bridge, the commu-

nication of water power is made by a copper pipe passing up in the axis of the bridge, through the middle of the centre girder, having a swivel joint at the lower end. Also, as the hand gear for the bridge-man rotates with the bridge, while the hydraulic turning engines are stationary, the communication for working the valves is made by a copper rod passing down through the centre of the above pressure pipe in the axis of the bridge. This rod is connected by levers direct with the regulating valves of the hydraulic engines, and the engines are reversed in either direction by the action of a small hydraulic cylinder, which is governed by the movement of a three-port valve, actuated by this rod from the bridge-man's platform. The cylinders for working the fixing gear at the ends of the bridge are worked by valves placed upon the centre platform, in reach of the bridge-man, the pipes between the valves and the cylinders passing along the side of the roadway of the bridge. The time required for opening or closing the bridge, including the locking of the links, is only half a minute, the average speed of motion at the extremities of the bridge being $6\frac{1}{2}$ feet per second. For the purpose of ensuring safety in the working of the railway line over the bridge, a system of self-acting signals is arranged, that is actuated by the fixing gear at the two ends of the bridge, and a signal of "all right" is shown by a single semaphore and lamp on the fixed part at each end; but this cannot be shown until each one of the resting blocks and bolts is secured in its proper place.

The paper was illustrated by a series of diagrams, to which, as the paper was being read, Mr. Westmacott directed attention where necessary, to render the details of the bridge more lucid and intelligible.

A discussion ensued upon the subject of the paper, and afterwards Mr. I. L. Bell proposed a cordial vote of thanks to the President for his able and valuable paper. Mr. Bell stated that nothing could exceed the perfect manner in which the work had been executed, and so gratified were the directors of the North-Eastern Company, that they had placed upon the transactions of the Board a minute, recognizing their entire satisfaction at the manner in which the work had been done.

The motion was carried with acclamation, and the President briefly acknowledged the vote.

The President announced that the directors of the North-Eastern Company had courteously offered to place a special train at the service of the members of the Institute, in order that on their return south on Saturday they might visit the bridge.—*Engineering.*

Mechanics, Physics, and Chemistry.

ON VARIOUS PROCESSES FOR PRESERVING TIMBER.

BY DR. ADOLPH OTT.

(Continued from page 198.)

THE light oil was found to be of no avail, for the wood treated with it decayed within the same period of time as wood that was not treated at all. The delay in time, in the decomposition produced by aniline oil, amounted only to 6.66 per cent., which, indeed, is a very insignificant period.

It is well known that carbolic acid affords an excellent means for preserving animal matter from putrefaction. This fact has led to the conclusion that the heavy tar oils would be as excellent for preserving wood, they being the chemists' source for carbolic acid. Rottier found this hypothesis unconfirmed. Decomposition set in after the usual period of time, whether the acid was employed in solution in benzine, or otherwise. Tar oils which contained not a trace of carbolic acid, proved to be just as effectual, or strictly speaking, "ineffectual," as oil to which a considerable portion of the acid had been added. Naphthalin has proved to be very powerful in protecting collections of natural objects against the ravages of insects. It might therefore appear that it was the proper agent for preserving wood. This is not the case; it being too volatile to be adapted for the purpose in question, where time and external agencies play such an important part. Quite favorable results were obtained with the greenish fluorescent oil, that comes over at the last stage of the distillation. Direct trials with pyren and par-naphthalin, however, did not yield successful results, wherefrom it must be concluded that it is the green fluorescent oil to which the preserving action of coal tar must be attributed. The only question which presents itself is, does the tar contain sufficient quantities of this fluorescent oil, so as to justify the employment of coal tar for preservative purposes?" From an extensive experience, and the collective testimony of others, I am inclined to answer this question rather in the negative than in the affirmative sense.

Importance of the protection of Forests. Lamentable results of their devastation.

In speaking of the supply of ship timber in this country, Mr. William W. Bates, of Chicago, Illinois, says:—*

* Report of the Commissioner of Agriculture, for the year 1866; page 490.

"From navy yards to cooper shops, from railroads to street-alleys, and from bridge-building to shingle making, there is no quarter given to the oak, and no peace to the pine. When we reflect that more than *sixty trades* and nearly *half a million artizans* flourish and prosper by consuming wood in manufactures in the United States, and that by far the greater proportion of woods used are the very kinds preferred in ship-building, it will become manifest that there is real cause for serious consideration of the subject of future supplies. Ship timber now costs nearly or quite double what it did ten or twenty years ago; and what is more, certain influences are at work narrowing the circle of woods eligible for construction, and thus increasing the difficulty of building a vessel for a moderate price. It will yet become a question of some importance among ship owners whether there are not other timber growths than oak and pine to be found in the forests of the United States, from which good and durable vessels may be built for reasonable prices. When a full and complete course of mechanical and philosophical experiments shall have made the commercial community acquainted with the timber properties of all the trees of our great country, of which the wisest must confess the want of information up to this time, many will wonder at the present general assumption that only a few kinds of trees would furnish timber fit for ship building."

And let us add with Frederick Starr:—

"When we remember that it is through their (the ships) instrumentality that those articles are brought which yield such a national income to the Government, surely wood stands forth, demanding again the acknowledgment of its value and power, which thoughtless men have never given to it."*

Let us look, besides, at the buildings of brick and stone, at the thousands of farm-dwellings, the manufacturing establishments, the railroads, everywhere we meet timber under a new aspect. Wood, according to the last mentioned author, pays more than one-half of the entire internal revenue of the United States. Let us glance on the other hand, at the desolation with which many once beautiful and fertile regions of Europe have been overwhelmed in the time of one single generation by the destruction of its forests. In considering the yearly devastation of our American forests, it becomes at once evident that the question of the saving of wood constitutes

* American Forests, their destruction and preservation. Report of the Commissioner of Agriculture, for the year 1865; page 233.

one of the most important subjects of political economy. Indeed, the interest of wood, according to Starr, will place the interests of cotton, wool, coal, iron, meat, and even grain, beneath its feet.

Fortunately, like the "cloud no bigger than a man's hand, just rising from the sea," a lively interest begins to awake on this subject. In the legislative halls, as well as in the rooms of scientific societies, in agricultural and technical periodicals, the subject of the preservation of wood is being discussed with an earnestness and eager search for truth, which must command our highest interest and participation.

Probable causes of the decay of Wood. On instances when timber does not rot.

In the foregoing, the author has endeavored to throw some light on various processes which have been brought to the notice of the public. Not having found any one of them perfect, he now proposes to discuss the main points to be kept in sight in any attempt for the solution of this most important problem.

The decay of timber, or the peculiar transformation which makes it unfit for practical purposes, seems to be in most instances produced by the attack of fungi and lichens.

Whether it be necessary that the sap upon which they thrive, should be in a state of fermentation, or whether it is seized when yet in an unchanged state, is not yet decided, but worthy of investigation. The access of air seems to be necessary in so far as the fungi themselves need oxygen; it is, however, improbable that the albumen is the only substance of the juice on which they are capable of vegetating, for the fact that the presence of albuminous substances is not conditional in other and well studied modes of fermentation. Timber is naturally more subject to rot when perforated by the larvæ of insects, or if deprived of its bark, or otherwise damaged.*

Trees which are hewn when the motion of the latex is greatest, are most susceptible to decay. Trees with an abundance of sap, as maple, red and white beech, are little durable. The sap wood

* The *mouldering* of wood is distinct from decay, it being merely a chemical process caused by the action of water with small access of air. This process requires centuries, and its consideration would therefore be of no practical importance in a discussion on the decay of wood. It is most probable that the lignites and mineral coals are the products of the mouldering of wood. The process alternately causes evolution of carbonic oxide, carbonic acid, and marsh gas. Instances of the preservative action of water upon (originally sound) wood, are the old Spanish dwellings of the Canaries, built in 1402, utensils from lacustrine habitations, and roots submerged in marshes. Hartig describes a submerged cypress stem with over 3000 year rings, of which the innermost are said to be perfectly compact and little altered.

always rots first. Wood, on the other hand, when well seasoned, and kept in dry situations, generally withstands decay for a considerable length of time, but if exposed to dampness, it will soon begin to rot.* Timber that has already undergone decomposition, may be saved from further destruction by being subjected to steaming in close chambers. This is explained by the fact, that the microscopic plants mentioned, or their spores, are killed by an elevated temperature.

"Perhaps the most simple and practical method for preserving timber," says William Bates,† "is by subjecting it properly to the action of water and air. By the action of *water* it may be deprived of all those vegetable matters contained in it which are soluble in water, and which by heat and moisture, are caused to ferment and rot. * * * * By the action of *air*, the water and moisture contained in the timber may be evaporated, and the fibres of the wood be brought closer together by the loss and shrinkage of the vegetable matters deposited between them."

With respect to the first step, it may be mentioned that it is an ancient practice in England to steep the oak planks for threshing floors, and those intended for the wainscoting of houses, in running water. Timber, treated in this way, is said to endure for an immemorable time; but this process, though effectual, is by far too slow to be practicable. Again, when such wood is placed under conditions favorable to decay, it will soon begin to rot, either because only part of the sap has been withdrawn, or because foreign substances have gained entrance. Moreover, such wood is always liable to warping and shrinkage; it will check and crack, and when connected with other materials, as in buildings, it will check and crack them also.

* The hygroscopic nature of the wood prevents the total expulsion of water by air drying, for Rumford found that air dried woods heated to 277° Fah., lost weight (per cent.) without being altered, as follows:

Oak wood lost.....	16.64
Elm	18.20
Beech	18.66
Maple.....	18.63
Fir	17.63
Birch.....	19.38
Lime.....	18.79
Poplar.....	19.65

(*Encyclopedia of Chemistry*, by James C. Booth, assisted by Campbell Morfit. Second edition. Philadelphia, 1862. Article, "wood.")

† Vide his article on Ship Timber in the United States, in the Report of the Commissioner of Agriculture for 1866 : page 494.

(To be continued.)

SOLAR ECLIPSE OF AUGUST 7, 1869.

(Continued from page 216)

REPORT OF ALFRED M. MAYER, PH.D.

(Chief of the Burlington Section of the Philadelphia Photographic Expedition.)

To Prof. Henry Morton, Ph.D.

DEAR SIR:—I herewith present to you my report, as chief of the Burlington section of the Photographic Expedition, organized by you under the authority of Prof. J. H. C. Coffin, U. S. N., Superintendent of the Nautical Almanac.

This report is given under the following heads:

1. Diary of work at Burlington up to the time of the Eclipse.
2. The Station, with a Map of the same.
3. The Equatorial and its Adjustments in Altitude and Azimuth.
4. The Camera and Chronograph.
 - (a.) The adjustment of the Reticule of the Camera.
 - (b.) The experimental determination of the time of exposure during partial phase.
5. The Work during the Eclipse.
6. Description of the Photographs taken.
7. Results.
 - (a.) Time of First Contact.
 - (b.) Position-angles of first and fourth contacts.
 - (c.) Angles of position and heights of the protuberances.
 - (d.) Measurements on the solar spot in S. W. quadrant.
8. Observations on the application of Photography to the determination of the times of contacts during the transits of Venus in 1874 and 1882.

1. *Diary of Work at Burlington up to the time of the Eclipse.*

Our party, consisting of Messrs. O. H. Willard, H. C. Phillips, J. Mahoney, O. H. Kendall, Miles Rock (who accompanied the expedition as my special assistant), and myself, arrived at Burlington, Iowa, about noon on Wednesday, Aug. 4.

We were here received by Prof. Coffin, who had previously selected our station of observation, and on it had erected a building to contain the equatorial, with adjoining rooms suitable for photographic purposes. The afternoon was occupied in the transportation of our boxes to the observatory and in unpacking and mounting the telescope; while Mr. Willard made some additions to the

photographic rooms and modifications in their arrangement. We had progressed so well with our work that by sun-down we had put together the base and frame of the telescope, had mounted bed-plate, polar and declination axes and circles and the cradle which holds the telescope tube.

On Thursday, Aug. 5, the tube was placed in the cradle and all the parts of the telescope were put together and oiled. The verniers were now adjusted opposite each other, and the instrument was brought into altitude adjustment to within 1' by the process described below.

Mr. Austin, of the Nautical Almanac Office, at the request of Prof. Coffin, had previously run a meridian line on the cross timbers which supported the base of the telescope and, as near as could be determined, I brought the polar axis and this line into one plane. This forethought of Prof. Coffin greatly expedited the bringing of the equatorial into position, and I afterwards found from star observations that the azimuth adjustment required to be touched but slightly.

We rose on Friday morning, Aug. 6th, to see a driving rain, with an east wind, and the same dull murky atmosphere which we had had all the day before. Yet we went on attending to the details of arrangements for the coming day as though we *could* not be disappointed after weeks spent in previous preparation for the work of to-morrow, and after having come over a thousand miles to carry back with us the long thought of eclipse, fixed on our plates in *appearance, time and position*.

As we retired there appeared a breaking away in the clouds and Dr. Gould told the clerk in the office to "wake us up if the stars came out." We had barely lost ourselves in cloudy slumber when the clerk knocked at the door with "Get up! *plenty* of stars!" We were soon dressed and came out to be charmed by the sight of a cloudless sky, and Prof. Coffin, Dr. Gould and I were up all night, putting our own special instruments in adjustment, and, at the same time, helping each other as we could. When all was finished the sun was rising over the trees on the opposite bank of the Mississippi and the air was as pure and as serene as one could wish.

On Saturday morning the chronograph was mounted and wires were led to the camera, to Prof. C. A. Young's spectroscope and to the station of Dr. Gould outside the building. The two threads of the reticule of the camera were placed one parallel and the other at right angles to the celestial equator. Mr. Willard now began ex-

periments to ascertain the chemical focus and his success in this delicate adjustment will speak for itself to all who examine the beautiful details of the photographs.

It is here important to remark that the chemical focus was obtained after the tube had been following the sun for an hour or more, and after the focus was fixed, the clock-work was kept going so that *no change in focus* should supervene from a change in temperature in the lenses and tube; which change of focus certainly would have occurred if we had closed the roof of the observatory and had uncovered only a short time before the eclipse.

By 3 P. M. all was in readiness and each one at his allotted post of duty ready for work. We were now surrounded by a clear, soft atmosphere without the slightest haze, and no trace of clouds except a small low bank on the western horizon. The temperature of the air was 71° Fahr.

2. The Station.

The station selected for us by Prof. Coffin was situate on an eminence known as South Hill in the south-west part of the town of Burlington. The enclosure was a level square of ground thickly covered with clover grass and surrounded by a hedge. It was elevated about 175 feet above the river, and its quiet and freedom from dust rendered it admirably suited to our purposes.

The accompanying plan, made under my direction, by Mr. Miles Rock, C. E., will show the plan of the building and the position of the instruments, observers and photographers during the eclipse.*

The latitude of our station in Burlington is 40° 48' 21.58" N. Longitude, 0 h. 56 m. 13.88 s. W. of Washington. It was about 7 miles north of the centre of the moon's shadow.

3. The Equatorial and its Adjustments.

The equatorial was borrowed from the observatory of the Central High School of Philadelphia, and is by Merz and Mahler of Munich. It is of 9 feet focus and 6.42 inches aperture and was mounted on one of Fraunhofer's wooden stands. It has a driving clock, the movement of which is governed by the friction of revolving arms against the inner surface of a cone, and by bringing the knobs (which terminate the arms and are attached to them by springs) to run against

* As this map was of large size and not essential to the understanding of any important point, it was not thought desirable by the Committee on Publications to have it engraved.—ED.

a larger or smaller circumference of the cone we obtain a greater or less velocity of clock-movement.

The stand of the telescope rested on massive cross-timbers firmly rammed in the ground.

The object-glass of this instrument had a light brownish tinge, which it is important to remember, as it may have had some effect on the chemical action at its focus.

The probability of cloudy weather immediately preceding the eclipse, caused me to use the following method of adjustment; and it is well I did, for otherwise I should not have been able, in the few hours when the stars did appear, to have brought my telescope into the exact position I did.

I had the cap, which covers the object-glass, centered on a lathe and pierced with a hole. The object-glass and eye-lenses were removed and a plumb line was let fall from the hole in the centre of the cap through the hole of the cap of the ocular. When the line was brought to the centre of the hole of the eye-cap, the axis of the telescope was vertical. The vernier was now read, the tube brought to a vertical position on the other side of the polar axis and the vernier read again. The difference of readings gives twice the angle formed by the vertical with the polar axis, and, if the polar axis is elevated to the latitude of the place, will equal twice the co-latitude of the station. If the angle obtained is too great, close it by elevating the polar axis, if too little, open it by depressing the axis.

I thus, assisted by Mr. Rock, adjusted the telescope to within $1'$. The error read was $30''$. I say within $1'$, for $1'$ on a radius of 9 feet is $\cdot 03132$ inch, and a deflection of the line $\frac{1}{8}$ of an inch from the centre of the ocular cap will give a deviation from *centrality* of *twice* that quantity, or $\frac{1}{4}$, (about $\frac{1}{8}$ inch); for we measure with the eye from the *sides* of the hole to the line and not from its centre to the line, so the difference of these measures is twice the deviation.

As stated above, the polar axis was brought as near as could be in one plane with the meridian line previously traced and the azimuth adjustment, tested in the following manner, required only a slight alteration.

To bring polar axis into the plane of the meridian.—Select an equatorial star and place micrometer thread so that the star glides along the thread when the telescope is moved in right ascension. The thread is now nearly parallel to the equator. Select a star about three hours off the meridian, say W., and bring it on equatorial

thread of micrometer and set the clock going. If the star, (as seen in a refractor with a direct eye-piece) *rises* above the thread, then N, end of polar axis, is E, of the meridian; if the star *falls* below the thread, then N, end of axis, is W, of meridian plane. If an E star is used, then the above rule is reversed (E for W, &c.)

After each adjustment the equatorial wire is reset to the equator, and the operations are continued until star neither rises nor falls.

On the night of the 8th—7th this adjustment was effected and the clock, after much trouble, regulated until it drove the tube so that a star was closely bisected for about twenty minutes. During the adjustment of the clock the precaution was taken to place the tube to about the same elevation it would have the next day during totality.

4. *The Camera and Chronograph.*

The image of the sun was formed on the plate of the camera by the action of a negative eye-piece, the lenses of which were so placed by Mr. Zentmayer in relation to the object-glass and to each other, that the diameter of the sun's image, on a $4\frac{1}{2} \times 5\frac{1}{2}$ inch plate, was 2.04 inches. This image was therefore not the direct image formed by the object-glass, but, according to De la Rue's plan, adopted and judiciously modified by you, it was the magnified image of the direct image which was used.

(a.) The adjustment of the reticule of the camera.

Mr. Zentmayer had so constructed the camera eye-piece that the image of a reticule of two spider threads, at right angles to each other, was formed on the plate with the image of the sun, and these threads were so mounted that they could be adjusted respectively parallel and at right angles to the celestial equator, and thus fix on the photographs the positions of the sun and moon, and give the position-angles of points on the surface and periphery of the sun. This adjustment I deemed of great importance, as without it we would not obtain the position-angles of contact nor the positions of the protuberances during totality. The lines are nearly as sharply defined on the pictures of totality as on those taken during partial phase.

The adjustment was made as follows: The camera was firmly screwed to the telescope and the focussing tube was moved until the images of the sun and threads of the reticule were brought to exact focus on the ground plate. The well-defined spot in the S. W. quadrant of the sun was now made to travel along the thread, by clamping the telescope in right ascension, and the reticule plate

revolved until the spot was accurately bisected during all its progress across the field. The telescope was then unclamped in right ascension (still remaining clamped in declination), and moved around the polar axis so that the spot ran along the thread; it was found to be bisected throughout all its transit.

Dr. Gould, at my request, now examined the adjustment and pronounced it precise.

(b.) The experimental determination of the time of exposure during partial phase.

The tube carrying the camera lenses screwed into a plate, in which, immediately in front of the anterior lens, was a guide in which a thin plate, having a horizontal slot of $\cdot0224$ inch in width, was caused to descend by the action of a spring.* Any integral ray of the beam whose rays successively passed this slot, traversed the plate only during the time it took the slot to fall its own breadth, or the $\cdot0224$ of an inch; and the determination of this time,—being the time of exposure,—has been the object of an experimental investigation which is given below.

During *totality* the full aperture of object-glass was employed and a slide-plate was used which had a circular opening, which allowed the full beam to pass. This plate had two falls instead of one as was the case with the $\cdot0224$ inch slide used during partial phase. On setting the plate free by the top trigger it fell, and the collodion plate was exposed to the entire beam; after the desired exposure a lower trigger was relieved and the plate made a second fall and, the lens being covered by the top of the plate, the exposure ceased.

After my examination of the photographs I realized the importance of an accurate determination of the time of exposure during partial phase, so that those who should hereafter attempt similar work might have the full benefit of our experience. This I considered all the more important because our results are apparently as perfect as any heretofore attained, and therefore *the time* which gave these results should be accurately known.

A reference to the diagram of the camera will render clear the method of registering on the chronograph and also the process by which I determined the duration of the flash of the sun which fixed his image on our plates.

During the eclipse the registration on the chronograph was ef-

* The construction was such that the plate could be made to descend by the action of 1, 2 or 8 springs; only one was used by me for the exposures of both partial phase and of totality.

fects as follows: A circuit passed from the face plate A B to the chronograph through the trigger K, and the spring attached to the binding screw L, which latter was insulated from the slide by being fixed to the wooden camera box. On tapping the trigger K, the pin, P, of the slide, being relieved of support, the slide fell, and the circuit was broken by the spring under the trigger no longer touching the top of the spring L. Thus a break circuit was obtained, at the instant of each exposure, which was duly registered on the chronograph.—(See Plate I., opposite.)

The arrangement of apparatus and circuit for the determination of the time of exposure was as follows:—

From the break-circuit clock of my observatory I led a wire to one pole of a battery, thence by the other pole to the plate at H; from this plate the current went through the trigger K and spring at L to a Morse register; from the register by a wire which led back to the clock and thus completed the circuit. Another short stiff wire, O A, was attached to the binding screw L, and reached from L to a short distance beyond the slot, A, and was in front of the surface of the face-plate, A B, but so near to it that when the slide fell, the projecting pin, P, would strike the wire about $\frac{1}{10}$ th of an inch above its lowest point of fall.*

Now, suppose the projecting pin P to rest on the trigger K, while the spring under the trigger rests on the top of the steel spring attached to L, and that a paper fillet is running through the Morse register; then at every second the clock will for an instant open the circuit and there will be a very short break made in the line marked by the pen on the fillet, and thus the seconds of *time* are stepped off in *space* on the paper ribbon. Suppose now that the long end of the trigger K be sharply driven by the blow of a hammer against the face of the camera; the circuit will be *open* during the fall of the pin from the top of the trigger to the point where it strikes the wire, O A, projecting from L, and there will be produced in the line on the fillet a *break*, whose length compared with the length of the second in which it occurs will give the time required for the plate to fall the above mentioned distance. It is evident that as soon as the pin strikes the wire the circuit is again closed, and the clock breaks the circuit as before the fall. I always struck the trigger at about a half second so that the comparison could be readily and accurately made.

* The wire, O A, is represented in the engraving, bent upward at its end, A; it should be straight.

We have given an engraving of a fillet, which shows the break at the seconds and during the fall of the plate.

The fall being accurately measured and the time of that fall known, the time the plate takes to fall .0224 inch, which is the time of exposure, can be accurately computed.

Before giving the results of these experiments I should remark that the plate descends with an increasing velocity produced by the action of the decreasing force of the spring, and what I obtained was the mean velocity of the plate. Also, the time it took the pen of the register to leave the fillet at demagnetization and to return to the fillet at magnetization is neglected, and as I had no means of determining it I adjusted the force of current and of spring so that these motions were as rapid as possible. I do not think the time required for these motions has affected the results appreciably, especially as the fall was a large multiple of the breadth of the slot.

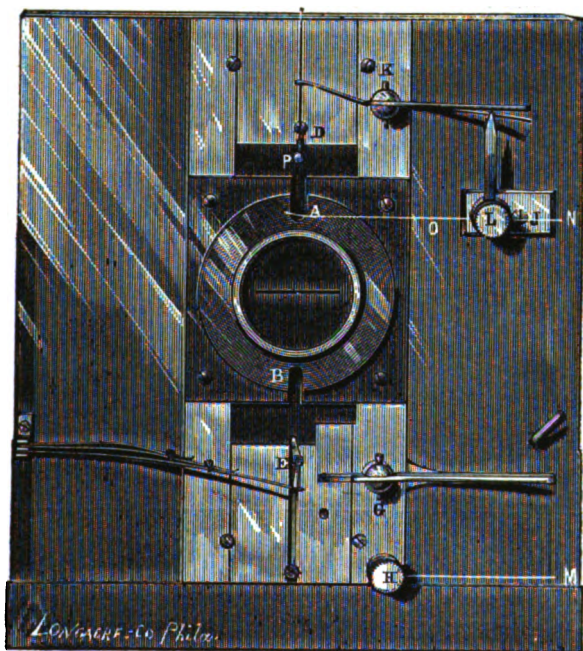
The breadth of the slot was measured under the microscope and the mean of three measures, at ends and middle, gave .0224 inch.

As an example of the manner of determining the time of exposure from the above data we will take the results of Fillet No. 1.

$$\begin{array}{rcl}
 \text{Length of second on fillet,} & .83 & \text{inch.} \\
 \text{" break during the fall of slide} & .105 & \text{"} \\
 \text{Fall of slide} & 1.340 & \text{"} \\
 \text{Width of slot in plate} & .0224 & \text{"} \\
 \hline
 \frac{.105}{.83} = 0.126 = \text{time of fall of slide through 1.34 inch.} \\
 \frac{.126 \times .0224}{1.34} = .00211 = \text{time of exposure.}
 \end{array}$$

No. of Fillet.	Length of ls. on Fillet.	Length of break on Fillet during fall of Plate.	Fall of Plate.	Time of Exposure.
1	.830 inch.	.105 inch.	1.34 inch.	.00211 second.
2	.765 "	.090 "	1.34 "	.00196 "
3	.790 "	.0975 "	1.34 "	.00205 "
4	.795 "	.100 "	1.34 "	.00208 "
5	.840 "	.120 "	1.34 "	.00237 "
6	.785 "	.095 "	1.34 "	.00202 "
7	.755 "	.110 "	1.36 "	.00231 "
8	.860 "	.120 "	1.36 "	.00228 "
9	.750 "	.100 "	1.36 "	.00211 "

Mean time of exposure..... .00214 "



INSTANTANEOUS EXPOSURE SLIDE.

Fall of Slide 1.34 inch.



COPY OF FILLET No. 5.

The greatest departure in these results from the mean is .0002. No. 2 being that quantity below, and No. 5 that amount above the mean.

The sum of the last column of figures equals 39; their mean 4.33; which shows that they are entirely of an arbitrary value, and if the experiments had been extended would no doubt eventually have equalled 4.5; we therefore reject the last decimal place, and adopt for our final result .0021 of a second. The time of exposure was therefore almost exactly $\frac{1}{500}$ th of a second!

5. *The work during the Eclipse.*

As before stated, by 3 P. M. of August 7, all was in readiness for our work. Mr. Willard had used every precaution to ensure success in the details of photographic manipulation, and the results which he reached will show with what judgment and skill he had organized all the workings of this department. The accompanying plan shows the position of our party, and also of Professors Coffin, Gould and Young during the eclipse.

It was my duty (2 on plan), to keep the telescope in adjustment, and to manipulate the apparatus of exposure and chronographic registration, while Mr. Willard (5) placed the plate in the camera and gave me the several times of exposure he desired during totality. Mr. H. C. Phillips (7) coated the plates and handed them to Mr. Montfort (photographer of Burlington), who carried them to Mr. Willard, and thence after exposure to Mr. Mahoney (8) who developed, assisted by Mr. Leisenring.

The plan shows the exact dimensions and position of the photographic rooms, and needs no description to render it clear.

M. Miles Rock, C. E., was detailed to attend to the very important duty of calling and tapping the seconds on the chronograph fillet; in this duty he was relieved by Mr. Bonsall, of Burlington. Mr. O. H. Kendall called out the minutes, at each 60 second call of Mr. Rock, and wrote it on the fillet. He also had charge of the chronograph, and started it when I called "clock," while at the same signal, Mr. Rock began the registration of seconds.

I laid out the following programme of work:—1st. To take in rapid succession, beginning ten seconds before the computed time of first contact, a series of five photographs. 2dly. One just before second contact, one just after second contact, as many as possible during totality, one just before the end of totality, and another just

after the sun appeared. 3dly. To take again a series in rapid succession about the end of the eclipse. 4thly, During partial phase to take a photograph every four or five minutes,

To accomplish this, I placed on a table before me, a watch set to the face of the chronometer, whose indications we used during the eclipse, and on a slip of paper pasted to the table, I wrote in very black lead-pencil the computed times of 1st, 2d, 3d and 4th contacts. These I obtained from Professor Coffin. I thus could give Mr. Willard due notice when the plates should be prepared.

When the face of the chronometer marked 12 h. 48 m., Mr. Rock began to count and register the times on the fillet. Every one was at his post, the lanterns lighted, and nothing could be heard but the count and the tap of the chronograph. At 12 h. 49 m. 45 s., I took the first photograph, and following at intervals of 11, 10·8, 15·2 and 12 seconds, we secured five perfect photographs. The contact is first visible on the third. We now leisurely took photographs at intervals of about four minutes, until we had taken twelve plates in all. The moon's limb had now advanced to about three minutes of time of the spot in the S. W. quadrant. Professor Young, of Dartmouth College, who was stationed near me, stated his intention to signal as soon as the umbra was bisected by the border of the moon. The plate was prepared and all was ready. Professor Young signalled, I tapped the trigger; he remarked, "you must have shot it on the wing." The 13th plate (No. 15), shows the spot as nearly cut in half as I can estimate, by a careful comparison of this drawing with another of the spot, as photographed on the preceding plate.—(See Plate III.)

About five minutes before totality, Mr. Willard removed the diaphragm of two inches aperture, which was used during partial phase, and exposed the full aperture of the object glass, while I changed the slide with ·0224 inch slot for the one which admitted the whole beam at once on the plate of the camera.

The order was given to prepare the plates. We took the first plate at 13 h. 51 m. 39·15 s., or 7 s. before the time of second contact, as observed by Professor Coffin. I soon had the slide reset for another exposure, and as Mr. Willard desired the first plate of totality to be exposed five seconds, I kept on counting zero, zero, zero, with the taps of the chronograph when, striking the upper trigger at zero, I counted 1, 2, 3, 4, 5, when the lower trigger was struck and the plate removed.

Counting the first plate, taken seven seconds before second contact, I took six photographs in 2 m. 3 s. After the sixth was removed, I looked at watch and saw 50 s. yet of total phase. There was a delay in the plate. I grew impatient. I called plate! plate!! but alas, it was found impossible to manipulate more than six plates in two minutes and three seconds. We had used up our store too rapidly, and so did not succeed in getting an impression just before the sun came forth. The next plate was taken 29.2 seconds after third contact, and is a valuable photograph of a thin crescent with the cusps sharply cut.

As has already been explained, under the head of camera, at each fall of the slide, the electric circuit was broken, and a registration made on the fillet alongside of Mr. Rock's second marks taken from the chronometer, and it is evident that all of these registrations are vitiated with whatever personal equation affected him at that time. This was not determined.

About fifteen minutes before totality, it became so cool that I was obliged to put on my coat. A minute or two before totality, the sky grew ashen, or rather leaden in hue, and as, with face turned towards the sun, I kept the count from the chronometer for the first exposure, Venus and Mercury came out shining beautifully on a ground of bluish grey. I thought I saw a flashing twirling motion in the corona, or in the last rays of the sun; but of this I will not be positive, for my attention was not, at the time, specially directed to minute observation. Moths and insects in profusion passed between me and the sun, while a flock of birds with troubled irregular flight seemed seeking cover from the unnatural gloom which surrounded them. A low moaning wind now sprung up, and the whole atmosphere seemed filled with a leaden colored vapor, and I experienced an indescribable feeling of oppression when—I tapped the trigger; and from that instant until the sun appeared, I had nothing but an *instrumental* consciousness, for I was nothing but part of the telescope, and all my being was in the work which I had to perform. I reset slide, made circuit, exposed, and so over again, until the six photographs were taken, when I had the mortification to find fifty seconds of totality, and that no plate could possibly be obtained; we were *too* quick.

Photographs were now taken leisurely, at intervals of about four minutes, until 14 h. 47 m. 48.4 s., when the first of the series for the end of the eclipse was secured; this was followed by four others

at intervals of 1 m. 16.84 s., 29.26 s., 24.3 s., and 21.55 s. Our work was finished, and in a few seconds the eclipse of August 7th, 1869, was of the past, but its history we had faithfully recorded in forty-one perfect photographs.

Such good success as attended our efforts speaks for the entire devotion of each one to his allotted duties. Without this devotion on the part of each and all we would have failed, and the harmony and efficiency which pervaded our corps need no other witness.

6. *Description of the Photographs taken.*

We took four photographs during the eclipse. They are all good, but some are superior to the others, and these will be designated as I proceed.

The plates were numbered with a diamond before the work began, and the numbers corresponding to those on the plate are given below, and opposite them the times when they were severally taken. These times were measured off from the chronograph fillet, and correspond to the face of the chronometer, which marked Burlington sidereal time, with an error of 11 m. 58.3 s. slow.*

No. of Plate.	Time when Taken.		
2	12 h. 49 m. 45.25 s.		
3	12 49 56.		
4	12 50 5.8		
5	12 50 21.1		
6	12 50 32.95		
8	12 53 5.3		
9	12 56 3.2		
10	12 57 33.4		
11	12 59 17.6		
12	13 2 18.1		
13	13 7 23.3		
14	13 12 19.27		
15	13 15 14.24		
16	13 22 57.5		
17	13 20 55.6		
18	13 32 58.0		
19	13 37 41.5		
20	13 41 50.6		
21	13 46 34.1		
22 (5 s. exposure)	13 51 39.15		
24 (5 s. ")	13 52 3.1		
25 (7 s. ")	13 52 31.3		
23 (7 s. ")	13 52 54.5		

* 1869 August 7. 12 h. Sid. T. + 11 m. 58.30s. slow.

Daily change..... + 5.55 s. loses.

No. of Plate.	Time when Taken.	
26 (7 s. exposure)	13 h. 58 m.	12-37 s.
27 (7 s. ")	13	58 42-2
28	13	55 1-2
29	13	57 20-5
30	13	58 5-5
31	14	2 41-0
32	14	7 14-67
33	14	11 33-5
34	14	16 59-6
35	14	23 1-5
36	14	29 21-5
37	14	36 38-5
38	14	44 33-1
39	14	47 48-4
40	14	49 5-24
41	14	49 24-5
42	14	49 48-8
43	14	50 10-35

All the photographs show a beautiful gradation of shade from the border of the sun inwards. This *shading of the source of light* is due to the absorption of the peripheral rays which necessarily pass through a greater thickness of the dense solar atmosphere than those which emanate from the central portion of the disc.

On a more searching examination of the relative intensities of light of different portions of the solar disc, we observe on all of these photographs, close to the limb of the advancing or retreating moon, a bright glow like that of early dawn, which extends from the moon to a distance of about 15".

Thinking that this might be subjective and due to the strong contrast existing between the bright image of the sun and the contiguous black lunar disc, I made the following experiments.

I covered the image of the moon with a disc of white paper of its exact diameter. The plate was now inclined to the light so that the sun and the paper surface had as nearly as possible the same white tint, while the photograph was viewed against an illuminated ground formed by a sheet of white paper, placed before the window. Under these circumstances, the glow remained the same in all the photographs examined. Among others, plate No. 11 (which is the best photograph of partial phase in the series), shows this glow unequivocally.

Plates Nos. 21 and 30, are excellent photographs of thin crescents of the sun; the first taken 5 m. 12 s. before, and the second

3 m. 33.5 s. after totality. This glow, if it really exist, should show in these pictures an increased illumination in the points of the cusps when the light of these portions of the periphery of the sun is compared with an equal breadth of the sun's border, taken on that portion of its limb the farthest from the moon's. To make this comparison, I covered with white paper both the moon and the dark ground surrounding the sun, and inclined the plates as in the above experiments, so as to destroy irradiation from juxtaposition of the light and dark surfaces. This method of examination showed a distinct illumination in the narrowest portions of the horns of the crescents.

No such glow is seen on the periphery of the sun, although this is contiguous to the dark ground of the plate, and on covering the latter the appearance remains the same.

I am therefore convinced that this glow really exists, and if it cannot be accounted for in node and in *measure*, by diffraction, it must be due to a lunar atmosphere; though, I confess, I cannot understand how an atmosphere capable of producing such marked effects, when projected against the intensely lighted disc of the sun, should have no appreciable refractive effect on small stars, and especially on double stars, when occulted by the moon.

This glow can be distinctly traced on plate No. 11 to 18'' beyond the limb of the moon.

A minute examination of these photographs reveals a coarsely granulated or mottled surface extending over the sun, and especially well defined as we near its border. One is tempted at first to imagine that this is the well known solar granulation observed in the telescope; but familiarity with that appearance, as well as the reasons given below, soon decided me to reject the idea that this appearance on the photographs was really an impression produced by the image of the sun's granulation on the plate.

First, the granulations are many times larger than any ever yet observed; those on the photographs averaging 7.5'' in diameter, while those on the sun average 1'', and never exceed 3'' in diameter; 2dly, on plate No. 14 the mottling is very apparent, and encloses a space entirely free from granulation in the N. E. quadrant; no corresponding vacant space occurs in any of the other photographs; 3dly, the positions of these granulations are not the same on any two plates, as I found from very careful measurement; and 4thly, they are arranged in rows parallel to the sides of the plates, thus

showing conclusively that they have been produced in the photographic manipulation.

According to the photographs, sixteen well defined solar spots were on the sun during the time of the eclipse. In the N. E. quadrant, close to the sun's limb, and about 90° E. of N. is a remarkably beautiful and characteristic spot, greatly foreshortened from its position, so that the penumbra has disappeared on the west side of the umbra against which rest the large bright faculæ, which enclose the spot. Looking at it through a lens, you are immediately struck with the idea of a depression in the sun's surface, and you cannot help remarking how like it is in appearance to a lunar crater, for you are convinced that you look down *into* it, while the surrounding bright faculæ give a border similar to the white walls of some of the lunar mountains. From the south-western portion of this apparently elevated ridge, a large bright facula bridges over the cavity in a north-east direction, and divides the spot into two portions.

Plates Nos. 11, 16 and 21 show this object in perfection.

In the S. E. quadrant, we see three small and well defined spots, and several largely developed faculæ near the sun's limb.

In the S. W. quadrant is a large and well-developed spot, and near it, to the N., a group of four smaller ones. This large spot exhibited remarkable changes during the time of the eclipse, as will be seen from the drawings and measurements found under the head of "Measurements on the solar spot in the S. W. quadrant."

On close inspection, there is observed a very white projection from the surrounding bright surface of the sun, which stretches into the north-western border of the penumbra of this spot and reaches nearly to its numbra.

In the N. W. quadrant no solar spots are visible on the the photographs. About N. N. W. of the intersection of the threads of the reticule are observed what, at first sight, we might take for a group of spots, but they are specks of dust on the lens of the ocular, as they change their place on the disc with the threads, always preserving the same position in reference to them. This test will serve to distinguish other spots on the photographs, produced by the same cause—as, for example, the four spots on the S. E. quadrant.

Plate No. 4, which, fortunately, is one of the best photographs,

was taken 2·8 seconds after first contact, as observed by Dr. Gould. It shows a depression in the sun's limb at the point of contact, and from this depression shoots into the sun a high lunar mountain, whose position, measured from the S. point of the cusp, is one-fourth of the distance to the N. point of the same. Mr. W. S. Gilman, of New York, who observed at Sioux City, Iowa, informed me that he determined first contact by seeing this mountain peak thrust itself into the limb of the sun before a flattening took place from contact of the lower general surface of the moon. This mountain shows itself on all the photographs of the eastern limb, while other peaks appear as the moon progresses over the sun. The photographs show that the eastern limb of the moon is far more mountainous than the western.

Plates Nos. 4, 9 and 11, best show the mountains on the following limb; plates Nos. 31, 35 and 42, on the preceding limb.

The best method of examining these mountains is to cut with a sharp knife a disc of paper of the exact diameter of the image of the moon, and make its circumference coincide with the general level of the moon's periphery; the lunar mountains will then appear as black protuberances rising above the white circle of the paper.

Plates Nos. 39, 40, 41, 42 and 43, taken in rapid succession, as the moon was leaving the sun's disc, previous to fourth contact, show two prominent lunar mountains on the northern part of the cusp, followed by a long depression in the moon's limb.

Five photographs were taken during total eclipse, and one 6·85 seconds before, and one 29·2 seconds after totality. The one (No. 22) taken 6·85 seconds before the disappearance of the sun, shows all the prominences of the eastern limb; but on account of the long exposure, the thin crescent of the sun which then remained, caused a blurring of the details. The picture is a mixture of crescent and protuberances. The prominences, 6 and 7, are entirely isolated, while the intervening ones are enveloped in the light of the crescent.

Plate No. 28, taken 28·2 seconds after totality, is the photograph of a very thin solar crescent, whose cusps are sharply defined throughout. The northern horn is narrower than the southern, which causes the moon's disc to appear to depart from a circle curve.

No. 24, taken at 13 h. 52 m. 3·1 s.—that is, 17·1 seconds after totality, shows the full development of the prominences on the

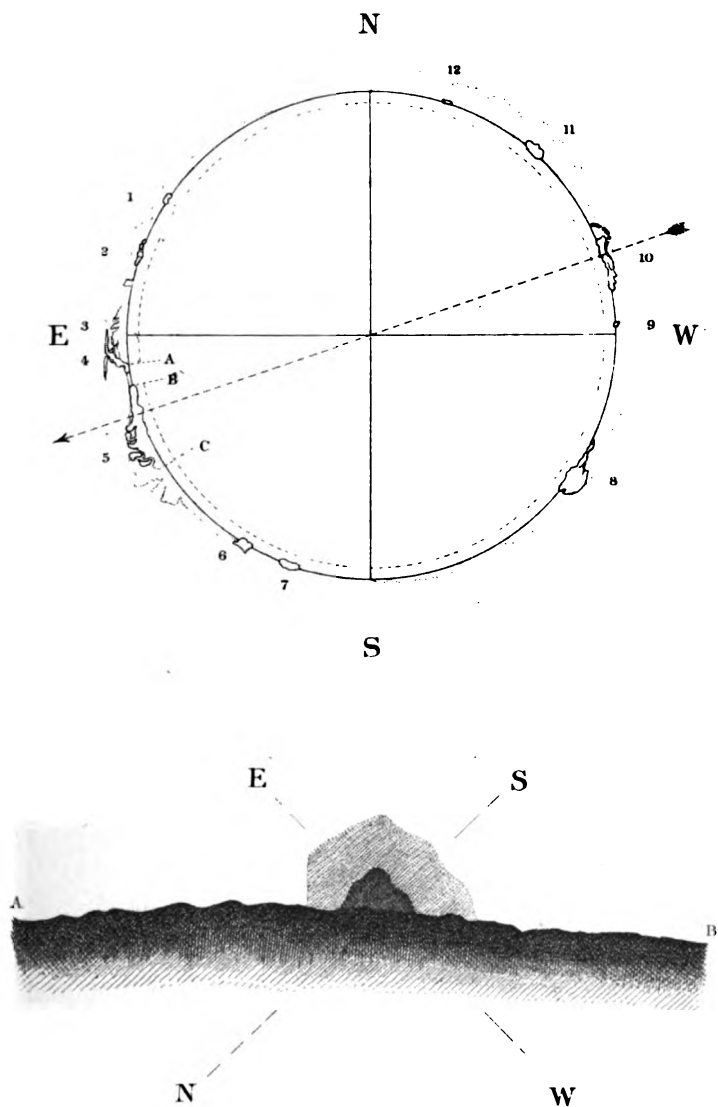


Plate 15.
13 h. 15 m. 14 s. 24.

eastern limb, while on the western only the top of the large southern protuberance (No. 8) is visible, and a slight glow appears on the N. W. and S. W. border.

Nos. 25, 23, 26 and 27, taken respectively 45.3 seconds, 1 m. 8 s., 1 m. 26.37 s., and 1 m. 56.2 s. after the disappearance of the sun, show the advance of the moon westward, and the gradual appearance of the prominences and glow on the western limb, while those on the eastern are being gradually cut off from view.

In No. 25, protuberance No. 8 is yet alone visible, while the glow appears along all the western border of the moon. Protuberances 1 and 2 are covered by the moon.

In No. 23, the glow on the western limb is about equal to that on the eastern. The tops of protuberances 10 and 11 are just visible, while 7 is just fading from sight.

In plate 26, on the western limb, prominence Nos. 9 and 12 have not yet come into view; No. 8 has already taken the form of the albatross head; No. 10 only appears like a grain of rice set on end; while No. 11 resembles two such grains standing on end near each other. The glow is now greatest on the western limb.

In plate No. 27, taken 40 seconds before the sun came forth, we see No. 8 as a fully developed albatross head with bill and throat close to the moon's border.

The small protuberance No. 9 now comes in view, and No. 10 assumes the shape of a caterpillar; 11 appears as a grain of wheat with a groove around its middle, and No. 12 comes in sight. On the moon's eastern border a mere trace of 6 appears, while 4 exactly resembles a bird sailing close to the surface of the moon. The group of protuberances, No. 5, which formerly appeared high above the body of the moon, floating in cloud, now rest upon its border.

This sketch will, I hope, give a general idea of the development and disappearance of the several flames, and show how rapid was the shifting of scenes during totality. All the changes I have described took place in 1 minute and 39.1 seconds, the time in which the five photographs were taken.

The accompanying diagram has been very carefully drawn from the results of measurements and calculations on the position-angles of the prominences.

I wish it to be understood that all of the measurements on the photographs given in this preliminary report were made on *copies* on glass, and not on the *original negatives*; also, that no microme-

tric apparatus was used, but only an accurate scale divided into half millimetres, the readings on which were made with a lens. These numerical results (except those of the position-angles and heights of the protuberances) are therefore only approximative, and the numbers to be used in a thorough discussion of the eclipse will be given as soon as accurate micrometric measurements can be made on the original negatives.

The protuberances are designated by numbers, from 1 to 12, going from N. through E. to N. The position-angles and heights are tabulated under the head of "Results."

The drawing and measurements of the prominences on the E. limb of the sun are from the first photograph taken, while those on the W. are from the last picture obtained. The diagram therefore shows the greatest visible development of these objects on the eastern limb, and those on the western are as they appeared 40 seconds before the end of totality.

Proceeding from the N. by the E. we perceive a glow of light which begins a little E. of N., and extends nearly to the S. point. This luminous fringe to the photograph (represented on the diagram by the irregular dotted line) reaches its maximum height about midway between prominences 2 and 4, there attaining an elevation of $2' 15''$. Another maximum of altitude occurs a few degrees S. of No. 5, where it has the same height. In the midst of this bright glow and near its greatest height appears at 3 and 5 detached sheets of bright flame floating above the lower mass of the conflagration.

The bases of the other protuberances are on the periphery of the moon, and *all* except No. 4 rest *below* the general circle of the moon's border. This appearance is *partially* explained by the fact that the telescope follows the motion of the protuberances, while the moon, therefore, has the difference of angular velocity between it and the sun. At the instant of exposure the portion of the prominence resting against the moon's limb is photographed; but, as the moon moves eastward during all the time of exposure, the prominence will appear as a *depression in the moon's limb*, for the latter has moved to a higher portion of an eastern prominence, and to a lower portion of a western, by the time the exposure is ended.

From the relative motion above referred to, it must necessarily follow that the border of the moon will not be well defined; but the eastern one will be more sharply cut than the western. All of the photographs of totality show this distinctly.

On plate No. 26, the apparent depression of prominence 11 is nearly all due to its being in the hazy limb; its base resting in a very slight depression.

The amount of depression of the prominences I have accurately represented in the accompanying diagram.

Proceeding from the north point to the east, we first meet with prominence No. 1, having the position-angle of about $56^{\circ} 30'$. It is of the shape of a rice grain, with its base but slightly below the circumference of the moon. In breadth it is $2^{\circ} 50'$ and in height $22''$. As $1'$ on the circumference of the sun equals 124 miles and $1''$ of arc at the sun's distance, on August 7th, subtends 449 miles, it follows that its actual dimensions are 21,000 miles long, and 9,900 miles high.

Protuberance No. 2 lies imbedded in the moon's border, and has in form the appearance of a short, deeply articulated worm. Its mean position is $69^{\circ} 17'$; its length $6^{\circ} 17'$, or 46,700 miles, and its greatest height equals $22''$ or 9,900 miles.

Between protuberances Nos. 2 and 3, are two flames in the midst of the glow previously described; one, near to No. 2, the other quite close to No. 3. Midway between Nos. 2 and 3 rises the diffused light to an elevation of $2' 15''$ or 60,500 miles. The position of protuberance 3 is $87^{\circ} 15'$ and it rises to a height of $1' 15''$ or 83,600 miles.

We now come to that curiously formed protuberance No. 4. Some have compared it to an ear of corn, but on the photographs it appears like an eagle, with outspread wings, resting on the trunk of a tree, which leans towards the north. On plate 27, where the tree stump is cut off by the advancing moon, the resemblance to an eagle on the wing is perfect.

The form of this object indicates instability, and impresses one with the idea that it is a great travelling whirl of flame, the direction of whose rotation—as indicated by the position of “the wings” and the projection of one on the other—is retrograde or in the same direction as the motion of the hands of a watch. I have examined with care the successive photographs of it, and although at first I thought that the last impression differed from those preceding, in that the wings had become longer and more in a line with each other, yet, on subsequent examination, I could not really decide that a perceptible motion had taken place during the time of totality.

The position-angle of the north side of the base of this object is

$96^{\circ} 25'$; its height is $1' 22''$ or 36,700 miles, and the spread of the wings, as measured on plate 27, is $9^{\circ} 31'$, or 70,800 miles.

Protuberance No. 5 reaches from B to an ill defined point beyond c of the diagram; it is of very irregular outline, and shows portions of its substance detached from the general mass, and floating freely above it. The most elevated and bright of these detached flames float at a height of at least 20,000 miles above the surface of the sun.

Beyond the point c, a white nebulous cloud rises to the elevation of $2' 15''$ or 60,500 miles.

Protuberance No. 6 of the diagram has a mean position of 148° ; its length is $3^{\circ} 5'$ or 22,900 miles, its height is $45''$ or 20,000 miles.

The position of the centre of No. 7, shaped like a grain of wheat, is $159^{\circ} 22'$; its length $5^{\circ} 13'$, equal to 88,800 miles, its height $37''$ or 16,600 miles.

We now pass to the western limb of the sun, and meet with the remarkably large and massive protuberance No. 8. It is shaped like an albatross head, with the beak and under side of the head resting on the limb of the moon. On a photograph taken at Ottumwa, Iowa, just before the sun came out, this protuberance had the exact appearance of an albatross head, with the beak open, holding a rounded mass between the extremity of the jaws. It lies between the position-angles of $230^{\circ} 13'$ and $245^{\circ} 46'$; its length is $15^{\circ} 33'$, or 115,700 miles, and its greatest height is $75''$ or 33,600 miles.

The small prominence, No. 9, has a position of $273^{\circ} 27'$.

Protuberance No. 10 bears the most striking resemblance to a caterpillar. Its mean position is $287^{\circ} 33'$, and it extends through an angle of 11° or 81,800 miles. Its maximum elevation, which is at the head of "the caterpillar," is $52''$ or 23,300 miles. Out of the head issue two horns; the one nearest the front being the higher of the two, and is terminated with a knob or ball, from which curves a broken line of light to the border of the moon.

The centre of prominence, No. 11, has a position of $318^{\circ} 33'$ and its extent is $5^{\circ} 18'$ or 37,400 miles, with an elevation of $44''$ or 20,100 miles. It has the shape of a grain of rice, slightly constricted in the middle.

The small protuberance, No. 12, has a mean position of 348° . Its length is $1^{\circ} 51'$, or 13,800 miles, and its greatest height is $15''$ or 6,700 miles.

The faintly dotted circle, inside the circumference of the moon, shows the relative diameter and position of the sun at the middle of total eclipse. The scale on which the diagram is made fails to show want of coincidence of the centres of these circles. The arrow marks the points of contact, and shows the direction of the motion of the moon.

7. *Results.*

Under this head, I give a few approximate results deduced from measurements on the glass positives; it being useless to attempt more until an accurate micrometric apparatus is brought to bear on the original negatives.

(a.) The time of first contact.

This determination was made by taking the mean of several measures of diameters of the sun's image on one of the plates, and from the known angle subtended by the moon deducing its diameter in the same unit of length; then the chord of the cusp was measured, and from these data the distances of the chord from the limbs of the sun and moon (or the versed sines,) were calculated.

From the known hourly motion of the moon (allowance being made for parallax), we obtain the time of first contact.

It is evident that if this measure be accurately made on the negatives, and the effect of refraction be also taken into account, we have precise data for determining the corrections necessary to be applied to the elements of the eclipse.

The time of first contact thus deduced from two plates, gave 12 h. 50 m. 2.94 s., which is 1.1 second before contact, as observed by Professor Coffin, and 0.1 second before Dr. Gould's observation. From measures on another plate (No. 5) we deduced 12 h. 49 m. 59 s., which is 4 s. before contact, as observed by Dr. Gould, and $\frac{6}{10}$ of a second after contact, as determined by Prof. Young with his new spectroscopic method of observation.

(b.) Position-angles of first and fourth contacts.

These position-angles we determined on plates 8 and 41, from the following measures.

Plate No. 8. Radius of sun = 31.4. Length of $\frac{1}{2}$ chord from N. point to point of contact = 18.25.

$$\frac{18.25}{31.4} = .5793 = \sin. 35^{\circ} 24'; \times 2 = 70^{\circ} 48'$$

Hence angle of first contact is $-70^{\circ} 48'$ or $+289^{\circ} 12'$

Computed angle . . . = -71°

Difference = $0^{\circ} 12'$

Plate No. 41. Radius of sun = 30.835 . Length of $\frac{1}{2}$ chord from S. point to point of fourth contact = 18 .

$$\frac{30.835}{18} = .5837 = \sin. 35^{\circ} 43'; \times 2 = 71^{\circ} 26' .$$

Position-angle of fourth contact = $108^{\circ} 34'$

Computed angle = $108^{\circ} 0'$

Difference = $+0^{\circ} 34'$

The points where the inner dotted circle of the diagram is cut by the arrow, shows the positions of contact as determined from the photographs.

(c.) Position-angles and heights of the protuberances.

The determinations of the position-angles and heights of the protuberances on the eastern limb of the moon are derived from measures on plate No. 24, the first taken during totality, and those on the western limb, from No. 27, the last plate of totality.

The measures were made in the following manner: On plate 24, only the reticule line on the eastern border is visible; but on plate No. 25, taken 28.2 seconds after, both eastern and western lines are sharply cut; and prominence No. 6 is nearly as fully developed on this plate as on that just preceding. I therefore obtained the exact angle of position of the south side of prominence 6, on plate 25; then, from this position, as point of origin of chords *on plate 24*, I determined the positions of prominences 4, 5, and 7. As the chords drawn from the south side of prominence 6 to protuberances 1, 2 and 3, were too long to give accurate determinations from their measures, I fixed the position of these prominences from measures made from the north side (point B.) of protuberance No. 5, previously determined by reference to the south side of prominence No. 6.

On plate No. 27, the reticule line on both eastern and western limb is distinctly photographed, and so this plate was alone used in determining the positions of the western protuberances.

The measurements were made on glass positives, taken directly from the original negatives by means of an orthoscopic lens, which enlarged the moon's image to a diameter of 2.47 inches. The

plates, firmly held by a wooden clamp, were supported about six inches above a board covered with white paper, and placed before a large north window. Sometimes the plates were parallel to the board, at others inclined, with the angle opening towards the window. This, I found, was the best illumination with which to examine the details of the photographs and to make measurements thereon. The legs of finely-pointed dividers were clamped to the proper opening, and with this radius arcs were struck, (cutting through the dark film of the photograph to the glass below,) having as their centres the points on the moon's border cut by the declination line of the reticule. Through the intersections of these arcs, a line was carefully drawn, which gave the diameter of the moon's disc which joined the N. and S. points of its periphery. Chords were now measured from the N. and S. sides of each protuberance to either the N. or S. points of position, according as the protuberance was in the N. or S. semicircle. Half of a chord being the sine of half the angle required, we can—having previously obtained the moon's radius—deduce therefrom the position-angle.

These measures have been made with the greatest care, and can, I think, be relied upon as accurate determinations. We do not think that, in this case, subsequent micrometric measures will add to their precision, for, from the difficulty of defining the exact boundary of the moon, (especially on plate No. 24,) the accuracy of the determination of radii will not be increased by attempting a micrometric measure of what we cannot see.

In the measurements a finely-divided millimètre scale was used, and the readings were made through a lens magnifying eight diameters.

The adopted radius of the moon, on each plate, is derived from the measures of four diameters, inclined 45° to each other. Every chord used is the mean of three measurements.

The measures, in millimètres, serving as data for the position, are as follows:—

Plate No. 29—second of Totality.

No. of Measure.	Diameter of Moon.	
1	66.4	
2	66.0	
3	66.2	
4	66.2	
Mean diameter.....		66.2
From S. point to S. side of prominence No. 6		R = 33.1
Length (measured on plate 24) "		= 17.4
		= 1.8

Plate No. 24—first of Totality.

No. of Measure.	Diameter of Moon.
1	66.3
2	66.1
3	66.25
4	66.3
Mean.....	66.24 R = 33.11
S. side of prominence 6 to N. side of prominence	7 = 4.2
“ “ “ “ S. “ “	7 = 7.2
“ “ “ “ N. “ (point B) “	5 = 27.0
“ “ “ “ S. “ (point C) “	5 = 17.65
“ “ “ “ N. “ of base of “	4 = 29.6
“ “ “ “ S. “ “ “	4 = 28.75
N. side (B) “ “ 5 to tip of S. wing of “eagle”	4 = .7
“ “ “ “ “ N. “ “	4 = 6.2
“ “ “ “ to centre of prominence	3 = 8.15
“ “ “ “ S. side of “	2 = 16.6
“ “ “ “ N. “ “	2 = 20.0
“ “ “ “ S. “ “	1 = 24.5
“ “ “ “ N. “ “	1 = 26.0

Plate No. 27—the last of Totality.

No. of Measure.	Diameter of Moon.
1	66.1
2	65.9
3	65.75
4	65.9
Mean.....	65.94 R = 32.97
S. point to S. side of prominence	8 = 23.5
“ “ N. “ “	8 = 35.8
N. “ centre “	9 = 45.2
“ S. side “	10 = 41.4
“ N. “ “	10 = 36.8
“ S. “ “	11 = 24.75
“ N. “ “	12 = 10.25
“ S. “ “	12 = 9.2

Table of the position-angles and heights of the Prominences.

No. Prominence.	Position-angles.	Height.
1	55° 9' to 57° 59'	22''
2	66° 14' to 72° 21'	22''
3	87° 15'	75''
4 (base of).....	96° 25' to 98° 4'	82''
4 (tip of N. wing).....	90° 39'	
4 (tip of S. wing).....	100° 10'	
5	101° 23' to 118° 36'	136'' (nebulous cloud.)
6	146° 25' to 149° 30'	45''
7	156° 46' to 161° 59'	37''
8	230° 18' to 245° 46'	75''
9	273° 27'	
10	282° 13' to 298° 12'	52''
11	315° 54' to 321° 12'	44''
12	342° 7' to 343° 58'	15''

Plate 4.

12h. 50 m. 5.8 s.

W

E

N

S

N

Plate 42.

14h 49 m. 48.8 s.

W

E

S

10' 20' 30' 40' 50' 60'

on drawings = 0.27 inch.
on the Sun = 449 miles.

As the moon glides over the solar disc, the angle of position of any protuberance, referred to the disc of the moon, is constantly changing, and the amount of displacement depends on its position in reference to the line of the moon's motion.

The position-angle of the S. side of prominence 6 was first determined on plate No. 25, and this point, thus determined, was taken as origin of chords on plate No. 24, taken 28.2 seconds before; but I find by computation, that the position-angle of the S. side of prominence 6, on plate 24, is $32^{\circ} 32''$ N. of what it is on plate 25; assuming, in the computation, that the prominence is stable in form and position on the sun's circumference. Therefore, it follows, that the position-angles of prominences 1, 2, 3, 4, 5, 6 and 7, as given in the above table, should be diminished by $32^{\circ} 5'$ to make them correspond to the position-angles they had at the time plate No. 24 was taken.

(d.) Measurements on the solar spot in the S. W. quadrant.

The drawings marked "Plate 4" and "Plate 41," were made with a camera lucida, the spots being magnified under the microscope to exactly 21 diameters. They show better than can be described the changes which took place in the dimension and form of this spot in the interval between the times of 12 h. 50 m. 5.8 s. and 14 h. 49 m. 48.8 s. Through each spot two lines are drawn, in the directions of the minimum and maximum diameters of the spot on plate 42. The lines on 4 are respectively parallel to those on 42, thus having the same position-angles.

On plate 4 we see umbra and penumbra of a general circular outline; the intensely bright projection into the margin of the penumbra is shown in the depression in the north-west border. The breadth of the umbra in the direction of the north-easterly and south-westerly line is $14.2''$, which equals, at the distance of sun on the 7th of August, 6,375 miles. Its width in the north-westerly and south-easterly line is $15.5''$ or 6,960 miles.

Plate 42 shows the change of dimension and of form which took place in 1 h. 59 m. 33 s. The circular outlines of umbra and penumbra having changed to elliptical boundaries, the direction of the longer axis being north-west and south-east. The umbra has widened in this direction $4''$, or 1,796 miles, and has, in the transverse direction, narrowed its breadth $5.25''$ or 2,357 miles, while the outward projections of the umbra (which can be identified in plate 4), have become greatly lengthened.

The breadth of the umbra in north-east and south-west direction is 9.6'' or 4,310 miles; in the north-west and south-east line it is 19.6'' or 8,800.

After the drawings had been made with the camera-lucida, a micrometer plate was placed under the microscope without deranging the instrument, and the magnified image of hundredths of inches on the plate were marked on the drawings. This gave directly the value of the magnifying power used, and by computation, the value on the drawing, in fraction of an inch, of 1'' on the sun's disc.

8. *Observations on the application of photography to the determination of the times of contacts during the transits of Venus in 1874 and 1882.*

We here venture a few remarks, showing the peculiar value of photography in the observations of the transits of Venus.

It has been shown that the sun's image was photographed on the camera plate with an exposure of only $\frac{1}{800}$ th of a second; and the duration of exposure for any other instrument can be determined with as great precision by the method which I employed.

The instant the mechanical movement exposes the plate, it also records the time of that exposure on a chronograph connected with a break-circuit clock, and thus we have an accurately delineated *figure* of the transit corresponding to a *time* marked on the face of the clock employed; and this correspondence of figure and time is unaffected with personal equation either of sight or of hearing. Now if the error and rate of the clock can be entirely freed from the personal equation of the observer who determined them, and if the longitude of the station be found by the coincidences of the beats of a sidereal clock with those of a break-circuit mean solar clock placed at the observatory of the first meridian, we have the most accurate means of obtaining the *absolute* times of contacts at the station of observation.

Thus we see how applicable will be photography to these observations; for the data of the solar parallax will be given either by observing the *absolute time* of the ingress or of the egress (which method is alone of value in the transit of 1874), or by determining the *duration* of the transit of Venus over the solar disc. The photographs are *permanent* phenomena on which we can repeat our measures at leisure, with every appliance of precision, while it is impossible to attain a similar degree with eye and ear, from the difficulty of micrometrically measuring at a *precise* instant the dis-

tance of Venus from the sun's limb, and from the (recorded) distortions of Venus at contacts.

It will also be of great value to have a photographic record of the appearance of Venus at the contacts, for, *if* the disc of the planet then should appear on the plate to depart from a circle and have attachments to the sun's limb, these distortions can be measured and allowed for.

An idea may be formed of the apparent size of Venus during its transit of the sun's disc, from the fact that the umbra of the solar spot in the south-west quadrant is $15''$ in diameter, and that Venus at transit will subtend an angle of about $70''$; so that the planet would appear on the plate as a disc $4\frac{2}{3}$ times the diameter of this spot, or, as a disc of $.107$ inch diameter on an image of the sun of 3 inches in diameter.

The negatives of these photographs I find from trial will stand a magnifying power of 50 under the micrometer, and as $1''$ of arc will equal $\frac{7}{10}$ th inch on a solar image of 3 inches diameter, we can, with the above mentioned power, divide a second into ten parts. This supposes, however, that the bisection by the micrometer thread is on a perfectly well defined point, and this does not exist in the outlines of any photograph, and especially is the limb of the sun indistinct on account of its shading, and of the manner in which the silver is deposited in the collodion film.

From actual experience in measurements under the micrometer, I find that we cannot, as yet, hope to make a bisection on the sun's limb closer than $\frac{1}{2}$ of a second. On the boundary of the umbra of a well defined solar spot, we can read to $\frac{1}{4}$ of a second, and from this I should think, that $\frac{1}{10}$ of a second might probably be attained as the limit in a reading on the limb of the image of Venus.

But with measures as close as these, and the tables of Venus brought to the accuracy which existing unreduced observations can give, we may reasonably hope for a determination of the solar parallax comporting with the most exact astronomical measures of this century.

The Lehigh University, Pa., 7th September, 1866.

SOLAR ECLIPSE OF AUGUST 7, 1869.

REPORT OF PROF. CHARLES F. HIMES, PH.D.

Prof. Morton:—

Dear Sir,—According to request, I make the following report of the section of the Photographic Corps organized by you and stationed at Ottumwa, Iowa, consisting of J. Zentmayer, J. C. Browne, E. Moelling, W. J. Baker, and myself.

The point of observation was finely located on a hill about a mile north-east of the city, in latitude $41^{\circ} 2'$, longitude $92^{\circ} 23'$ West of Greenwich, according to determinations of Professor Alexander, who happened to be located at the same place for astronomical observations.

On our arrival on Wednesday evening preceding the 7th, we found a very convenient shelter shed, with sliding roof and photographic room, erected under instructions from Professor Coffin.

The telescope was set next day upon a cross of timber firmly let in the earth. The clock work, not of very superior construction, was found to have become deranged by carriage, but fortunately the skill and experience of Mr. Zentmayer were available, and it was put in as good running order by him as it was susceptible of, otherwise we would have lost the opportunity for taking the totality negatives with a length of exposure sufficient to give the amount of detail and corona we obtained. It was deemed advisable, however, that Mr. Moelling should pay exclusive attention to the clock during the progress of the eclipse, in order to detect and correct any irregularity that might occur.

In the absence of any assistance from an astronomical party, the adjustment of the instrument and of the reticule for determining angles of position was mainly accomplished by Mr. Zentmayer, in a very satisfactory manner, in spite of the unfavorable weather preceding the evening of the 6th.

The morning of the 7th found the sky overcast, but gradually with a dry wind from the east, the clouds gave way, until at noon, not a trace of cloud or haze was to be seen. These few hours were improved by determining the actinic focus with great accuracy.

I placed the chronograph, a make-circuit one with two pens, in position, having connected one pen with the camera to register the exposure of the plates, and the other with a key upon which the seconds were to be tapped from a chronometer; but whilst it was found to act satisfactorily, having cause to fear that, by reason of the

fact that for want of sufficient force it had to be entrusted to volunteer parties, it might become deranged at a critical moment, I did not deem it advisable to trust our record to it alone, and immediately before the beginning of the eclipse, determined to make a record of the times from a chronometer kindly placed at my disposal by Professor Alexander, the correction for which, as given by him, will be found with the annexed schedule of negatives. I found it very easy to note the fraction of a second by the click of the exposure slide, warning having been given me before touching the trigger. I send this record because that made by the chronograph is not complete, and, perhaps, not reliable, as far as it goes, as the instrument became deranged during the progress of the eclipse. I did not find leisure, at the time, to examine and compare it, and, as I regarded the schedule of negatives complete without it, took the liberty to place it in the hands of Prof. Alexander, subject to your request, as he desired to examine it for the record of some of his astronomical observations which he had made upon it by means of the key of the seconds-tapper.

The photographic preparation was exclusively managed by Messrs. Browne and Baker, and the negatives obtained were photographically perfect. A statement by them of formulæ of Collodion, solutions, &c., will doubtless be made to you.

It was found necessary to increase the length of exposure by detaching two of the springs attached to the exposure-slide as the total phase was approached. The exposure during the partial phase I would estimate at from $\frac{1}{30}$ th to $\frac{1}{80}$ th of a second, with the aperture of the telescope reduced to two inches by a diaphragm placed over the objective. During totality, the full aperture was used, and exposures of six, twelve and sixteen seconds given, producing negatives of exquisite sharpness and detail, including a portion of the corona. The general plan of exposure was to obtain five negatives, if possible, near the contacts, and three near the beginning and end of totality, and at intervals of five and ten minutes during the other phases, and we have reason to be satisfied with the results. The one immediately preceding totality displays the limb of the sun beautifully cut up into Bailey's beads, and the one taken at the instant of the close of the total phase, received the first rays of the emerging sun, but is of interest as showing in this connection the red prominences. On this plan thirty-four excellent, accurately timed negatives were obtained, as given in annexed schedule, in

which D indicates diaphragm of two inches, F, full aperture; under *Length of Exposure*, under *Drop*, 1 indicates exposure slide with slit $\frac{1}{10}$ th of inch wide; 2, with slit $\frac{1}{30}$ th; 3, with slit $\frac{1}{40}$ th, and 4, with circular aperture size of eye-piece. Under *Spring*, 1, 2, 3, denote that one, two or three springs were used upon the exposure slide.

The distribution by you of the prints from negatives of last year at Aden, aided much in regulating developments and exposure.

Whilst we all feel fully satisfied with the results of our efforts, the success of which has been so largely due to the thoroughness of preparation in all details, and the use made of the experience of previous parties by you, we confess with observers of this phenomenon, generally, that we feel that our present experience would have been of great value.

We were necessarily excluded from extended observations beyond our special work, but there are several notes made that may be of interest in this connection.

I had watched the approach of totality, anxious if possible to obtain a negative with Bailey's beads, and was surprised with the sudden transition to comparative darkness at the instant of totality, and the peculiar brilliancy with which the stars seemed to spring out without the long struggle through twilight.

The corona approached much more nearly in regularity the four-rayed form generally given, and which had always seemed idealized or conventional. The S. W. ray was, however, unequally subdivided with the smaller part toward the north. The whole seemed of a fibrous, slightly curled or twisted character, somewhat like a cirrus cloud, and of silvery whiteness. The prominences, especially the large one a little to the left of south, seemed at the first instant of a dazzling white, but after my attention had been diverted for a few moments, it appeared of a brilliant decided rose color, bordering on crimson, and remained of this color to the close. To Mr. Zentmayer, who was engaged at the camera and had used neither telescope nor screen, it appeared white, with a slightly roseate hue. To Mr. Moelling, under similar conditions, it appeared white throughout. Messrs. Brown and Baker who had a short glimpse of it from the door of the dark room, rather incline to the opinion that they were white.

During the progress of the eclipse, Mr. Zentmayer, who examined the ground glass of the camera from time to time to notice the posi-

PHILADELPHIA PHOTOGRAPHIC CORPS.

Record of the Times and Lengths of Exposures of the Photographic Plates exposed during Total Eclipse of the Sun, at Ottumwa, Iowa, August 7th, 1869, as noted by C. F. Himes. Greenwich Time. To accompany report to Prof. Henry Morton.

No.	Time of Exposure.	Length of Expo.		Aperture.	
		Drop.	Spring.		
1	9 h. 59 m. 30 s.....	1	3	D	Lost.
2	10 h.....	1	3	D	
3	10 h. 1 m. 5 s.....	1	3	D	
4	10 h. 2 m. 5 s. (within a second.).....	1	3	D	
5	10 h. 3 s.....	1	3	D	
6	10 h. 4 m. 42 s.....	1	3	D	
7	10 h. 9 m. 55 s.....	1	3	D	
8	10 h. 14 m. 57 s. } Glass marked XI. } ..	1	3	D	Lost.
9	10 h. 19 m. 57 s.....	1	3	D	
10	10 h. 28 m. 55 s.....	1	3	D	
11	10 h. 32 m. 50 s.....	1	3	D	
12	10 h. 37 m. 28 s.....	1	3	D	
13	10 h. 41 m. 41 s.....	1	3	D	
14	10 h. 49 m. 22½ s.—glass 2d quality.....	1	3	D	Baily's Beads.
15	10 h. 55 m. 56 s.....	1	1	D	
16	10 h. 56 m. 38½ s.....	1	1	D	
17	10 h. 57 m. 36½ s.....	1	1	F	
18	about 6 seconds } Exposure	4		F	
19	Totality " 12 " }	4		F	
20	" 16 " }	4		F	
21	11 h. 4 m. 15 s. close of tot. and after tot.	4		F	Fogged a little.
22	11 h. 6 m. 12 s. ..	1	1	D	
23	11 h. 6 m. 52 s.....	1	3	D	
24	11 h. 7 m. 57½ s.....	1	3	D	
25	11 h. 10 m. 6½ s.....	1	3	D	
26	11 h. 16 m. 16½ s.....	1	3	D	
27	11 h. 22 m. 45½ s.....	1	3	D	
28	11 h. 29 m. 27 s.....	1	3	D	
29	11 h. 37 m. 57½ s.....	1	3	D	
30	11 h. 47 m. 58 s.....	1	3	D	
31	11 h. 53 m. 7½ s.....	1	3	D	
32	11 h. 53 m. 45 s.....	1	3	D	
33	11 h. 54 m. 12½ s.....	1	3	D	
34	11 h. 55 m. 12 s.....	1	3	D	
35	11 h. 55 m. 40 s.....	1	3	D	
36	11 h. 56 m. 10 s.....	1	3	D	
37	11 h. 57 m. 58 s.....	1	3	D	
38	11 h. 59 m. 55 s.....	1	3	D	
39	11 h. 59 m. 7½ s. by chronometer of different rate used by Prof. Alexander, and exposure made at signal from him at this time.	1	3	D	

D denotes aperture of two inches in diaphragm on objective.

F denotes full aperture.

Drop 1 indicates drop with slit in slide one-fortieth of an inch wide.

Drop 4 indicates drop with circular aperture size of eye-piece.

Spring 1, 2, 3, indicates number of springs used on drop.

tion of the image of the sun, called my attention to an appearance of small luminous bodies like meteors crossing the dark image of the moon from cusp to cusp. Subsequently, they were seen to pass over the ground glass from outside of the field on to the image of the sun, where of course they were lost, always coming from the same side. We were led by this circumstance to regard them as most likely to be optical illusions, perhaps insects with transparent wings or bodies, but the fact that other observers report a shower of meteors between the moon and the earth, which seemed to be as far as I can gather from a hasty description, identical in appearance with the objects noticed by us, our observation may be of considerable value, especially as Mr. Zentmayer, who saw most of them, is disposed not to regard them as optical illusions, since they must have been caused by objects not less than 2,000 feet distant.

I cannot omit to mention the friendly manner in which we were treated by the authorities and citizens of Ottumwa.

Favored as we were with a sky free from cloud or haze, and a beautiful point of view, this phenomenon left an inerascable impression upon our minds and hearts.

Dickinson College, August 1st, 1869.

Condensing Magnetism.—M. Jamin has communicated to the French Academy of Sciences a curious paper on a method of condensing magnetism similar to the condensation of electricity. He describes an apparatus made for him by M. Limet which consists of a horse-shoe magnet composed of ten bars of homogeneous steel bolted together, the two sides being covered with insulated wire connected with 50 Bunsen's elements. When magnetised this magnet will bear a weight of 300 kilogrammes at the armature. When this armature is placed in contact with one only of the steel bars the magnetism of the other nine is considerably diminished. Now, although the magnet was previously saturated with magnetism it is possible to make it take more, and bear 600 kilogramme. Another armature may be put on, so as to bear only on one of the component bars, and more magnetism can be condensed. M. Jamin has thus caused the magnet to carry 680 kilogrammes. This was done by applying five armatures; but as soon as they were detached the magnet returned to its primitive strength.

REPORT OF PROF. E. C. PICKERING, Ph. D.

*Mt. Pleasant, Iowa, August 9th, 1869.**Prof. Henry Morton:—*

Dear Sir:—The following experiments were conducted at the Brazelton House, in this town. Latitude $40^{\circ} 57'$; longitude $91^{\circ} 38'$. The room used was in the third story, and had an unobstructed view to the west.

The most important experiments during the partial phase were thermometric; for this purpose three delicate thermometers were used. An alcohol thermometer, A, divided to half degrees, and two filled with mercury, B and C, the latter having a blackened bulb. A was hung in the room, in the shade; B kept its case, so that its temperature was very nearly constant; and C was exposed directly to the sun's rays.

TABLE I.

TIME.	A	B	C	TIME.	A	B	C
3 7	23.3	23.1	40.8	5 10	23.0	23.1	26.4
20	23.5	23.0	40.8	15	23.2	.....	27.6
29	23.7	23.2	40.8	20	23.4	23.4	28.7
36	23.8	23.2	41.7	25	23.6	23.6	29.6
40	23.9	23.4	41.7	30	23.8	.....	31.0
50	24.3	24.0	42.2	35	24.0	24.0	32.0
55	24.7	24.0	42.0	40	24.3	24.0	32.4
4 0	24.7	24.0	41.8	45	24.4	24.2	33.1
5	24.9	24.0	40.8	50	24.5	24.2	32.9 ^a
10	24.9	24.0	40.6	55	24.7	24.3	35.4
15	25.0	24.0	39.7	6 0	24.6	.....	36.9
20	25.3	24.0	38.0	5	24.5	24.2	35.8
25	25.2	24.1	37.4	18	24.2	.....	34.8
30	24.7	24.0	34.9	20	24.3	24.0	34.1
35	24.4	.....	33.0	25	24.2	24.0	33.9
40	24.3	.....	31.8	30	23.9	.....	32.9
45	23.9	23.8	28.6	35	23.8	.....	30.7
48	23.7	.....	27.2	40	23.5	23.7	29.7
57	23.3	23.3	24.8	45	23.2	.....	27.1
5 0	23.4	.....	24.7	50	.....	.....	25.2 ^b
5	23.7	.....	25.3	55	22.7	23.0	23.4 ^c

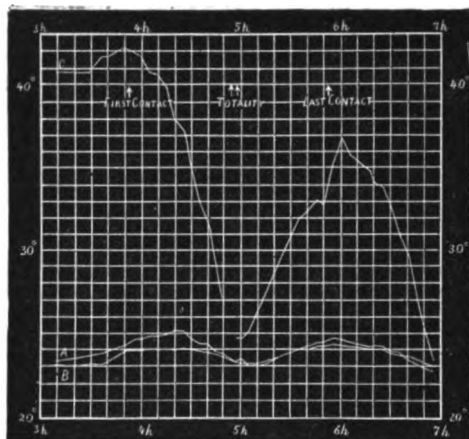
^a Shadow fell on C, causing the depression seen in the curve.

^b Sun reaches cloud near horizon.

^c Sun appears red through cloud.

Observations were made every five minutes after the eclipse began: at longer intervals before. The time is about a minute and a-half slower than the local time, or 56 m. 50 s. slower than Washington mean time. The temperatures are Centigrade, estimated to tenths of a degree.

The curves in the adjoining figure represent these results; Vertical distances give temperatures; Horizontal distances, times. They



11
THERMAL CURVES.

In the following table, the first column gives the number of digits eclipsed; negative numbers denoting distances between the two limbs. The second column gives the local time; the third, the temperature of A; the fourth, the estimated temperature, if there had been no eclipse. Of course, this is a very rough approximation, and was obtained by drawing a continuous curve through the beginning and end of the eclipse. It is only intended as a guide, and too much dependence must not be put on it. The last column gives the fraction of the sun's disc obscured.

By examining the third column of the above table, it will be seen that shortly before the eclipse the thermometer *rose*, attaining its maximum at the instant of contact, so that when three digits or 14 per cent. of the sun's disc was obscured, the temperature was about the same as before the eclipse. Again the thermometer continued to rise after the eclipse was over. These results were at first considered anomalous, but they were unexpectedly confirmed by the photographs of the sun taken at the same time. The increased brightness which these show along the moon's limb, prove

that the latter augments the actinic power of those parts of the sun's disc nearest it, and this renders the increase of heat also, very probable.

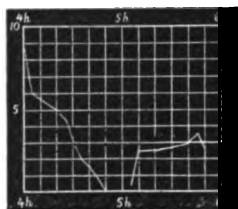
TABLE II.

Digits.	Time.	Temperature.		Obscur.	Digits.	Time.	Temperature.		Obscur.
		Real.	Assumed.				Real.	Assumed.	
— 8	8 8	40·8	.....	.....	12	4 59	24·7	39·5	1·000
— 7	13	40·8	.....	.....	11	5 4	25·1	39·3	·893
— 6	19	40·8	.....	.....	10	9	25·9	39·1	·789
— 5	25	40·8	.....	.....	9	14	27·1	38·9	·685
— 4	30	40·9	40·8	.....	8	19	28·2	38·7	·586
— 3	36	41·5	40·8	.....	7	24	29·3	38·5	·486
— 2	42	41·8	40·8	.....	6	28	30·1	38·3	·391
— 1	47	42·0	40·7	.....	5	32	31·3	38·0	·302
0	53	42·1	40·7	·0	4	37	32·1	37·8	·219
1	58	42·0	40·7	·029	3	41	32·8	37·6	·144
2	4 4	41·3	40·6	·079	2	45	33·5	37·3	·079
3	9	40·7	40·6	·144	1	50	34·4	36·9	·029
4	15	39·6	40·5	·219	0	54	35·2	36·6	·0
5	20	38·6	40·4	·302	— 1	58	36·1	36·3	.....
6	25	37·4	40·3	·391	— 2	6 2	36·1	.....	.....
7	31	34·9	40·2	·486	— 3	7	35·7	.....	.....
8	36	33·0	40·1	·586	— 4	11	35·3	.....	.....
9	41	31·7	40·0	·685	— 5	15	35·0	.....	.....
10	46	28·6	39·9	·789	— 6	19	34·4	.....	.....
11	51	26·4	39·8	·893	— 7	23	33·9	.....	.....
12	56	24·8	39·6	1·000	— 8	26	33·5	.....	.....

Columns A and B, in the first table, show that the temperature of the air falls but slightly. As the instruments were in the room, they were protected from radiation. Their maxima occurred some time after the first contact, owing to the gradual warming of the room by the sun. In the last column of the second table, the discs of the sun and moon are supposed to be of the same size, as the latter, in reality, exceeded the former by about one twenty-fifth, the area obscured would be somewhat greater. The error, however, is only about 1 per cent. for eleven digits, and much less for other parts of the eclipse.

Actinometric experiments by the method of Bunsen and Roscoe

Fig. 2.



Time. Shade.

40 35
5 30
20 25
25 20
30 15
35 10
40 8

Time. Shade.

10 1
5 8
10 25
20 25
35 16
40 30
50 25

were made, exposing pieces of sensitive paper every five minutes, for one minute to the sun, and then comparing them with a fixed scale. The series is enclosed, but the delicacy of the method does not

appear to be sufficient to lead to important results.

The Total Phase.

On the approach of totality the thermometric and actinometric experiments were given up, and the following observations made instead:—

General Observations.—A pocket-telescope magnifying about ten diameters was used. It was tied to the back of a chair by a piece of cloth, just tightly enough to make it remain in whatever position it was placed. This forms a convenient mounting, and by it the telescope can be moved steadily, and the sun or a star followed without difficulty.

The corona appeared as an irregular four-pointed star, with, of course, a black centre. Two of the rays were nearly vertical, and two horizontal, the left hand one pointing somewhat downward, while between it and the lower ray was a fifth smaller point. Its color was pure white: very different from the full moon, but resembling a cumulus cloud. Possibly the reddish tint noticed by many observers heretofore, may be a subjective effect due to the green color of surrounding trees or grass. Its texture resembled the ragged edge of a thunder cloud, or the crest of a wave torn by the wind. The striæ were not radial but spiral, as if the sun had been turned in such a way that the upper edge moved towards the east.

A very bright protuberance was seen on the lower edge of the sun; also, two others on the western side. The first, to the naked eye, appeared as much within as without the moon's limb, and, by irradiation, appeared to send rays some distance towards the centre. The sky presented the appearance it has during the morning twilight, the western horizon, however, being bright yellow.

I did not notice the sudden lowering of the temperature during

totality, although this was very perceptible to those in the open air; it would, therefore, seem that this is an effect mainly due to radiation.

After the reappearance of the sun, the corona remained visible for several seconds. Cocks in the neighborhood crowed repeatedly as the light returned.

The following star observations were made by Dr. C. Pearson, who also assisted in the actinometric observations. Mercury became visible at 4 h. 54 m., or two minutes before totality, and disappeared at 5 h. Venus was visible from 4 h. 51 m. to 5 h. 12 m., or twenty-one minutes.

Spectroscopic Observations.—A chemical spectroscope with one 60° prism was loaned me by Prof. Van Vleck, and was mounted in the way above described for the telescope. As no lens was placed in front of it, all the light which fell on the slit from a circle about 7° in diameter passed through the instrument. Turning it towards the sun before totality, the latter remained in the field. This is probably the best way to obtain the spectrum of the corona, as there is very little loss of light; the protuberances, however, are so small that their spectra would be faint, although the advantage of not having to move the instrument is a great one. The spectrum appeared to be continuous, with two or three bright lines, the brightest in the neighborhood of E, and the next near C; but as no dark solar lines were visible, these positions cannot be relied upon. The absence of the dark lines may be due to the want of brilliancy of the spectrum, although this was bright enough to have its upper and lower edges well defined.

Polarization.—The form of polariscope used was that adopted by Arago in his experiments on sky polarization. It consists of a tube about 20 inches long, and 2 inches in diameter, one end of which is closed by a double-image prism of Iceland spar, and the other by a plate of quartz. Looking through the former, we see two images of the latter, which, when the light is polarized, assume complementary tints. If, now, the corona was polarized in planes passing through the centre of the sun (as is generally admitted), when viewed through the polariscope, in one image the upper and lower parts should have appeared blue, and those on the right and left yellow; while in the second image these colors would be reversed, the yellow being above and below, and the blue on the sides. In reality, the two images were precisely alike, and both pure white,

but one was on a blue, the other on a yellow background. From this we infer that the corona was unpolarized, or, at least, that the polarization was too slight to be perceptible.

Although this does not prove that it shines by its own light, since polarization is produced only by specular, and not by diffuse reflection, yet these observations, and also those with the spectroscope, seem to render it probable. This view is also strengthened by the fact, that as the most distant portions are but about one hundredth part of the distance of the earth, they receive over ten thousand times as much heat per square foot.

The colored background mentioned above, shows that the sky, close to the corona, is strongly polarized, and since the tint is uniform on all sides of the sun, the plane of polarization is independent of the position of the latter—that is, the same on the sides, that it is above or below it. The most probable explanation of this most unexpected result is, that the earth beyond the limits of the shadow being strongly illuminated, acts as an independent source of light, and this being reflected by the air, becomes polarized in planes perpendicular to the horizon.

I am indebted to Mr. E. L. Wilson for the use of two Vogel's Photometers; and also to Messrs. Hover and Leisenring for assistance in the photographic experiments.

In conclusion, the new facts elicited may be summed up as follows:—An increase of heat and actinic power is observed in the beginning of the eclipse, caused by an increased brightness of the sun's disc near the moon's limb. The spectrum of the corona appears to be free from dark lines, but may contain two or three bright ones. Its striæ are spiral rather than radial, and its light is unpolarized. The sky adjoining it, however, reflecting light from the earth, shows strong signs of polarization.

Respectfully submitted,

EDWARD C. PICKERING

Solution of Uranium Salts not Fluorescent.—In the last number of *Les Mondes*, we find that M. Selhorst announces that the salts of uranium and cobalt do not fluoresce in Geissler tubes. We are glad to hear some authority announce this, having tried repeatedly to obtain the phenomenon with uranium salts but without success, notwithstanding the statements of Du Moncel and Becquerel.—Ed.

SPECTROSCOPIC NOTES.

By PROF. C. A. YOUNG, of Dartmouth College.—No. 2.

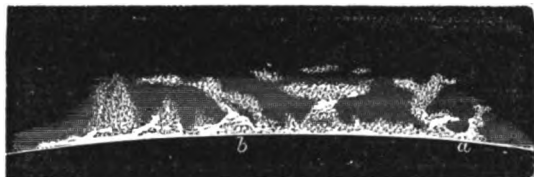
SEPTEMBER 4th, 1869.—Prominences were noted on the sun's limb at 3, P. M., to-day, in the following positions, angles reckoned from North point to the East:—

1. $+70^{\circ}$ to $+100^{\circ}$, very straggling, not very bright.
2. -10° , large and diffuse.
3. -90° , small, but pretty bright.

September 13th, 1869.—The following protuberances were noted this P. M.

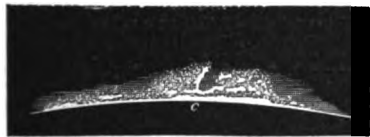
1. Between $+80^{\circ}$ and $+110^{\circ}$, a long straggling range of protuberances whose form was as in Fig. 1. I dare not profess any very extreme accuracy in the drawings, not being a practiced draughtsman, but the sketch gives a very fair idea of the number, form and arrangement of the immense cloudy mass, whose height was about $50''$ and its length $330''$ (22,500 miles by 1,350,000). The points *a* and *b* were very bright.

Fig. 1.



2. $+135^{\circ}$ small, but very bright at the base, of this form: (Fig. 2.)

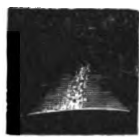
Fig. 3.



3. -85° of this form (Fig. 3.)

The dark spot, marked *c*, was very curious, reminding one strongly of the

Fig. 2.



so-called fish-mouth in the nebula of Orion. I saw no change in it for 20 minutes. On the other hand, the first series mentioned were changing rapidly, so that, at 5 o'clock, the sketch, which was drawn at 2 was quite inapplicable, only the general features remaining unaltered.

4. -128° , about $20''$ high, forked, thus:—

The structure was *cirrus* in every one but No. 3, which seemed more like a mass of *cumulus*.

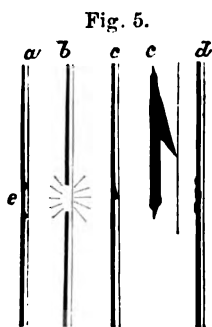
To-day, for the first time, I saw b_1 reversed in the chromosphere when the slit was tangent to disc; 1474 was easy; the new line at 2602 cannot be detected as yet.

Fig. 4.



At 2:25, while examining the spectrum of a large group of spots near the sun's western limb, my attention was drawn to a peculiar double *knobiness* of the F line (on the sun's disc, not at the edge,) represented by Fig. 1, *a* at the point *c*. In a very few

moments, a brilliant spot replaced the knobs, not merely interrupting and reversing the dark line, but blazing like a star near the horizon, only with blue instead of red light; it remained for about



2 minutes, disappearing, unfortunately, while I was examining the sun's image upon the graduated screen at the slit, in order to fix its position, which was at $-82\frac{1}{2}$, about $43''$ from the edge of the limb, about $15''$ inside of the inner edge of the spot-cluster. I do not know, therefore, whether it disappeared instantaneously or gradually, but presume the latter. Fig. 1, *b* attempts to give an idea of the appearance. When I returned to the eye-piece, I saw what is represented at Fig. 1, *c*, &c. On the upper (more refrangible) edge of *F*, there seemed to hang a

little black mote, making a *barb*, whose point reached nearly to the faint iron line just above *F*. As given on Angström's atlas, the wave-length of *F* is 486.07 , while that of the iron line referred to is 485.92 (the units being millionths of a millimètre). This shows an absolute change of 0.15 in the wave-length, or a fraction of its whole amount, represented by the decimal $.00030$, and would indicate an advancing velocity of about 55.5 miles per second in the mass of hydrogen whose absorption produced this barbed displacement.

The barb continued visible for about 5 minutes, gradually resolving itself into three small lumps, one on the upper and two on the lower line, Fig. 1, *d*. In about 10 minutes more, the *F* line resumed its usual appearance. I did not examine the *c* line, as I did not wish to disturb the adjustments and risk losing some of the curious changes going on under my eye.

After the close of this strange phenomenon, I examined, with our large telescope of 6-inch aperture, the neighborhood in which this took place, and found a very small spot exceedingly close to, if not actually *at*, the place. This was at 2.45 . At 5.30 it had grown considerably.

Undoubtedly, the phenomenon seen was the same referred to by Mr. Lockyer, when he speaks of often seeing the bright lines of the prominences not only at the sun's limb but on his disc. It is the only time I have had the good fortune to see it as yet.

The common fire-fly gives a continuous spectrum without any trace of lines, either bright or dark. It is noteworthy that this spectrum lies almost entirely between the lines *c* and *F*, the portion of the luminous diaphason where the thermal and actinic effects are nearly nil, and where almost all the energy expended is effective as pure light. How different from our artificial modes, in which not more than $\frac{1}{10}$ of 1 per cent. of the expended energy appears as light, the rest being mostly wasted in heat, and partly in actinism.

Hanover, N. H., September 18th, 1869.

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VOL. LVIII.]

NOVEMBER, 1869.

[No. 5

EDITORIAL.

ITEMS AND NOVELTIES.

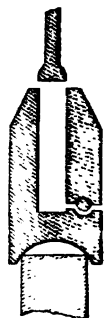
Pile Drivers.—After witnessing the beautiful and efficient operations of the gunpowder pile-driver, I have been led to inquire into the principles of its efficiency. Why will a hammer, falling through a certain height and forced upward by gunpowder, be more efficient than a hammer which is forced upward by other means? In the gunpowder hammer, the first important thing to be observed is—*the hammer does not strike the pile*. The plunger in front of the hammer compresses the air in the cavity in the cap, and, if the plunger fitted air-tight, it would form an air spring between it and the plunger, and as soon as the forward motion was arrested, it would, by reaction, force the hammer upward. But in this case, the compression of the air, by evolving heat, explodes a charge of gunpowder, and the expanding gases produces an

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37

intensified gaseous spring. In this way the iron in the hammer is prevented from coming in contact with the iron of the cap, and the pile is forced forward by an *intense, powerful push*, and not by impact, as in ordinary cases. It may, however, be considered a case of elastic impact, and analytical investigations show, that in elastic impact there is no work lost. In the ordinary pile-driver only a portion of the work of the fall is expended in driving the pile, the lost work being expended in bruising and destroying the head of the pile and the hammer.

These principles suggest an improvement in the drop-hammer and in the direct-action pile-driver, which is illustrated in the annexed figure. Let the lower end of the hammer be provided with a plunger passing nearly air-tight into a cavity in a cap over the pile, the same as in the gunpowder pile-driver. But, as it will not pass in air-tight, some of the air will escape from the cavity, under which condition the plunger could not be drawn out without producing suction, and hence a lifting force on the pile. To prevent this, make a small air passage near the bottom of the cavity, which shall communicate with the external air, and in this passage place a puppet or other valve, which shall let air freely into the cavity, but which shall automatically close when the air attempts to escape. The passage might enter the bottom of the cavity, and a flap of leather or rubber be placed over it.



Another principle in its economical working, consists in forcing the pile down by the same force which drives the hammer upward. In ordinary machines, the steam or other power which drives the hammer upward does not, at the same time, drive the pile downward. From this it appears, that if all the external machinery, in both cases, be left out of the question, it would be as economical to expend twice as much for powder power as for steam power. This statement, however, would not be true for a direct-action pile-driver, in which the engine rests upon the top of the pile, for in this case the engine would press downward while the hammer is being raised.

The external machinery for operating the hammer has little to do with its efficiency, so long as it is in order, but the almost entire absence of machinery in the powder driver, and especially of any machinery which will get out of order, is a novel and commendable

feature. But as the machinery for operating ordinary pile-drivers run a long time without repairs, the main question with the practical man will be the economy of the driving power. D. V. W.

University of Michigan, Oct. 12, 1869.

The Ejector-Condenser.—In the latter part of this number will be found the paper on this subject, read at the last meeting of the Institute, by Mr. J. R. Napier, and some remarks by various members.

The action of this instrument is so curious that in addition to the practical details of its structure and operation a few words respecting its "rationale" may not be out of place. The principles applied to the explanation of the *injector* by the present writer in an article on p. 54, Vol. LVI., of this Journal, and developed in a more general form in a brief discussion, on "Resistance and Transmission of Motion," in Vol. LVI., page 344, will apply fully to this case.

Referring to Mr. Napier's paper, with its accompanying plates, for a description of the apparatus and its working, we will only here remark that with it the exhaust steam from the cylinder after expansion, and with an absolute pressure of but $2\frac{1}{2}$ to 3 lbs. per square inch or $12\frac{1}{2}$ to 12 lbs. *below the pressure of the atmosphere*, flowing into a series of nozzles where it meets a stream of water and is condensed, is able not only to eject itself against the atmospheric pressure and to carry the condensing water with it, but even to lift this latter from a depth of several feet, or force the entire stream to a corresponding height.

How is this seeming paradox to be explained? We think, as follows:—

The steam, whose pressure is reduced to but 3 lbs. per square inch above an absolute vacuum, is for the same cause expanded to about five times its normal bulk or that which it would have at atmospheric pressure, or, comparing it with water, would have a bulk about 7050 times as great as the water from which it was formed and consequently would be contracted to $\frac{1}{7050}$ of its bulk if condensed into water.

Now, in fact, as it flows out of the nozzle, this very condensation happens to it, and supposing the jet to maintain simply the initial velocity due to the feeble 3 lbs. pressure, it would form a cone of which the steam-supplied base would be 7050 times larger than the condensed-water apex.

But the pressure of 3 lbs. per square inch is acting on the large base, and by reason of the motion given to the particles, is transmitted to the small apex; so that, considering this point alone, we see that the pressure of 3 lbs. per square inch at the first point might become 7050×3 or 21,150 pounds per square inch at the latter.

It will be of course evident to any one that the contraction of the jet is here the result of its condensation simply and thus has no effect upon its forward motion any more than the running together of the passengers on a steamer would have on her velocity, and is in no wise related to such contractions as are produced by a nozzle, or conical tube in which the forward motion is resisted by the very inclined surfaces which affect its concentration. The only office of a surrounding tube is to guide the stream and to prevent indraught of air which would otherwise be set in motion to the detriment of the legitimate work of the steam and water jets.

We may, indeed, compare the effect of the scattered particles in the dilated steam as they condense in the jet, to the result of a concentrated fire on a point of fortification, and should it be suggested that the same effect might result without condensation we can answer that it is *only by this* means that so many particles can be made to act at once within so small an area, and without waste of their moving force in effecting the concentration.

But we have made no account of the water required for condensation, this also must be set in motion by the escaping jet.

Suppose 20 lbs. of water are required to condense each pound of steam, and that this water, having no head, must receive all its motion from the steam, then, clearly, the velocity of the jet will be reduced to $\frac{1}{21}$ st. of what it was before, when thus applied to moving a total weight 21 times as great; but to carry the same quantity at a velocity reduced 21 times, the area of the stream must be increased 21 times: thus the small end of our *cone of condensation* would be enlarged 21 times for this cause, and the base and apex, in place of being as 7050 to 1 would be as 7051 to 21.

Not only, however, have we rendered the apex of our cone larger by reducing the velocity as above, but we have also increased its size, in an equal degree, by adding the additional volume of water, which, with the condensed steam, makes a volume 21 times as great as the latter: in other words, not only does each pound of water take 21 times as much room to pass at $\frac{1}{21}$ of the velocity, but there

are 21 times as many pounds of water to pass. We must then enlarge the small end of our cone 21 times again for this reason; it thus becomes 21×21 or 441 times as large as on the first supposition of the steam condensing without the addition of water, and the relation of the large end to the small one becomes 7050 to 441.

Now, on the steam end, as we have seen, is a pressure of 3 lbs. to the square inch, while on the water end of the cone of condensation is the atmospheric pressure of 15 lbs. But $7050 \times 3 = 21,150$, while 441×15 only equals 6,615, or less than one-third the former, therefore the condensed steam and water would be ejected with great force under the conditions assumed.

But let us see how far these conditions can be realized in practice, and first, to save repetition, let us remark, that the effect of the steam pressure is diminished in proportion to the square of the added weight of water. This is evident by inspection of the discussion just given.

By reference to the table in Prof. Rankine's report of October 27, 1868,* it will be seen that the average amount of heat taken up by the water was about 40° .

Let us assume the latent heat of the steam to be 972° , the feed water to be at 40° , and the discharge at 80° , as it was, in some cases, the "*round numbers*" being most convenient; then to condense the steam would imply an absorption of 972° and to cool it from 150° (about its presumable temperature at 3 lbs. absolute pressure) to 80° , would require a further absorption of 70° , or in all 1043° , which must be taken from each pound of steam to reduce it to water at 80° . As each pound of water in passing from 40° to 80° absorbs 40° of heat, each pound of steam will need $1043 \div 40 = 26$ lbs. of water for its condensation and cooling. The outlet of the ejector must then be enlarged 26 times by reason of this increased amount of water which is to be passed through it, and if there is no head to give this water the requisite velocity, the escaping steam must give up a corresponding amount of its motion to this water and so reduce its velocity 26 times to move this superior weight, as a result of which the outlet must be enlarged 26 times again to admit the escape of the liquid at this reduced rate, its area therefore becomes 676 times as great as it would have been could the steam have been condensed without addition of water. This, of course, greatly changes the relation of the steam and water ends of our imaginary cone, which in place of being as 7050 to 1 are as 7050 to

* This report has been crowded out of this number, but will appear in our next.

676, or about as 10·4 to 1, yet even then we have the pressure or force of 3 lbs. per square inch on 10·4 of area exerting a force of 31·2 decidedly superior to the atmospheric pressure of 15 lbs. per square inch on the area 1 of the outlet.

It must be here remembered that we have assumed the absolute pressure of steam or vacuum to be 3 lbs. throughout, while the diagram, and our judgment show us that it is far greater at the beginning of each exhaust, in consequence of which the steam will arrive at the base of the *cone of condensation* with a velocity due to this excess of pressure, and so exert an additional force which has not entered into our calculation as given above.

In thus treating this question as a statical rather than a dynamical problem, we depart from the usual method, but, in the first place, gain unquestionably much in brevity, and more in clearness of explanation to those not habitually familiar with mathematical work, while we sacrifice nothing in accuracy.

The best proof of this, to those who have not time to go into the merits of the question, is found, we think, in the fact that numerical results deduced by this process, agree precisely with those obtained by the highest authorities in the usual and less evident method. This, in the classical explanation of the Injector, by Prof. Ch. Combes, Inspector-General and Director of the *Ecole des Mines*, translated in this *Journal*, Vol. XXXIV., p. 325, the maximum quantity of water which a Giffard Injector could introduce with a constant pressure of 75 lbs, is shown to be 18·7 times the weight of the steam in *addition*, or *with* the condensed steam 19·7 times.

Now, at 75 lbs. pressure, the volume of saturated steam is 388 times that of the water into which it would condense. Therefore, the areas of the base and apex of its cone of condensation would be as 388 to 1, and the concentrated pressure on the smaller area would, therefore, be 388 times that of the boiler. The added water, however, as we have seen, diminishes this concentration in proportion to its square by enlarging the smaller end, first by its volume, and then by its reduction of the velocity: therefore, the square root of 388 or 19·7* will express the amount of water, which would reduce the proportion to an equality—*i. e.*, make the pressure per square inch of the injected water like that of the escaping steam, equal to the boiler pressure, thus implying that the steam was just able to enter the boiler against its pressure, without any allowance for friction. But this is exactly Prof. Combe's result.

* This root is strictly 19·692, &c.

Steam Omnibuses.—At a recent meeting of the Glasgow police court, Messrs. Honeyman and Drummond obtained the sanction of the authorities to run steam omnibuses, by way of experiment, on the streets of Glasgow.

Submarine Pumping.—A number of submarine sweet-water springs are known to exist along the coast of Istria and Dalmatia. As the coastal districts of these provinces suffer from want of a sufficient supply of water, and it is possible by means of the Norton pump to save much that is now lost, the Austrian Ministry of Agriculture has published a book on the means of finding and utilizing submarine fresh-water springs on the Austrian coasts.

Rust of Iron Ships.—Prof. Calvert has given some interesting results of his experiments into the nature and condition of rust. Oxidation of the bottom of iron ships, he thinks, may be prevented by an external coating of a preparation of an alloy of lead and antimony, while an alkali is placed in the bilge water within the vessel.—*Mech. Mag.*

The Suez Canal.—The Suez Canal Company has just issued regulations for the navigation of the Suez Canal, to be opened on November 17th. Article 1 states that the navigation of the Suez Maritime Canal will be open to all ships without distinction of nationality, provided their draught of water does not exceed $7\frac{1}{2}$ metres, the depth of the canal being 8 metres, equal to 26 English feet.—*Mech. Mag.*

Removal of Gas Works in London.—The great city gas companies are preparing to remove their works from the midst of the crowded localities in which they are now placed, and carry them into the country. The existence of these works in their present position has long been a grave nuisance. The Imperial Company has secured a location in the fields near West Ham; the Chartered on the river bank, near the northern outfall of the great main-drainage system; and the City Company, at Blackfriars, will, it is believed, migrate in the same direction. It is to be trusted that all the metropolitan gas companies will presently find it to their interest to remove entirely without the boundaries of the thickly-inhabited districts.—*Lancet.*

Damp Walls.—Our attention has of late been called to the question of rendering the walls of buildings impervious to moisture. We have received letters upon the subject from correspondents who ask us to point out a remedy for the evil. We therefore gladly

take the opportunity of making known to our readers that there is a remedy, at once simple and efficacious. This is a process invented by Mr. Frederick Ransome, and which is being successfully carried out in practice by the Patent Stone Company, East Greenwich. It consists in the employment of colorless mineral solutions which possess the property of forming an insoluble and indestructible mineral precipitate when applied to buildings. The deposit takes place not only on the surface of the material to which it is applied, but enters the body of the substance. The application of the solution in no way alters the color of the material, a perfectly natural appearance being preserved in the building. The effect is permanent, neither atmospheric nor saline influences in the least degree affecting the indurating material. It not only renders the building water-proof, but it further most effectually indurates and preserves from decay the stone or bricks treated with it. This process has recently been applied to several buildings which are stated to have been untenable, previously to the application, on account of exposure to a wind-driven rain. Paper now hangs well on the walls from which it formerly drooped in festoons and tatters, whilst dryness and a cleanly appearance have taken the place of dampness and mildew. This process of rendering buildings impervious to wet is comparatively inexpensive, therefore no one need longer to suffer from that source of discomfort and danger to health, damp walls.—*Mech. Mag.*

Gas-tight Rubber Tubes.—India-rubber tubing is slightly permeable to gas. As a fact, the amount which escapes through the walls of the tube is very small, but there are places in which it may be advisable to render any escape impossible. This can be done by giving the tubing a thin coating of a varnish made by dissolving one part and a-half treacle and two parts of gum-arabic in seven parts of white wine and three and a-half parts of strong alcohol. That is the receipt of M. Jouanne, but we have no doubt that beer may be substituted for white wine without harm. The treacle and gum must first be dissolved in the beer or wine, and the alcohol must be added very slowly, constantly stirring the mixture, or the gum will be thrown down.—*Mech. Mag.*

Old Shoes Converted into Combs.—Old shoes are not altogether wasted, but they have been put to a new use by M. Guyot. He cuts them up into thin shreds, and treats these with chloride of sulphur. Under this treatment, the shreds at first swell up and

then become friable and brittle. When this stage is arrived at, they are washed, dried, and ground to a fine powder, which we are told is of a grey rose color. This is mixed with some gummy or glutinous matter, and the mass is pressed into moulds to form combs, buttons, knife-handles, and such like articles. During the treatment with chloride of sulphur, it must be mentioned that the vapor of hydro-chloric acid is given off, which, on hygienic grounds, requires to be condensed. Then, when the shreds arrive at the brittle state, it is necessary to remove the excess of chloride of sulphur, and, we imagine, sulphur also. This is done by washing with sulphide of carbon, the recovery of which demands precaution. Taking all things into consideration, we doubt whether M. Guyot can make much profit by his process for converting old shoes into combs, although, by putting on the head what was once on the feet, he may, in one sense, be said to make both ends meet.—*Mech. Mag.*

Water-proof Fabrics.—M. Neuman has discovered a new way of water-proofing, or, rather, of making fabrics impermeable to water. The operation is simple, but it must be carried on with care, or the fabric will be ruined. It consists in submitting the tissue it is wished to make impermeable to the action of moderately strong sulphuric acid (57° Baume) for a space of time varying from a second or two to two minutes, according to the nature of the fabric. By the action of the acid the fibres, whether of wool or cotton, are superficially decomposed into a glutinous material. As soon as this has happened (the time required must be found by experiment) the fabric is passed rapidly through water, and well rinsed and finally dried, first in the air and then over cylinders. The glutinous matter will, of course, fill up all spaces between the threads, and no doubt the fabric will be made impermeable. Another way of effecting the same object is to completely dissolve cotton or linen in sulphuric acid, and spread the solution over the fabric either by means of cylinders or a brush. Calendering seems to be advisable in both cases.—*Mech. Mag.*

Naphtha as Fuel.—The attempts to employ naphtha as fuel have at length proved successful. On July 31st a train arrived safely in Kutschujan, 81 versts from Charkoff, whose engine was heated with raw naphtha instead of coals. The honor of the invention is ascribed to the mining engineer Portski.—*Mech. Mag.*

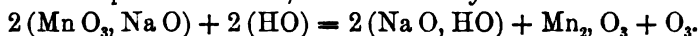
Mr. James Young, so well known in connection with the paraffine industry, has presented 10,000 guineas to Anderson's Uni-

versity, Glasgow, for the purpose of founding a chair of technical chemistry, and establishing bursaries, scholarships, &c. Mr. W. H. Perkin, F.R.S., who, it will be remembered, delivered a course of Cantor lectures before the members of the Society of Arts during the last session, has been appointed the first professor.—*Chem. News.*

Oxygen Manufactured on the Large Scale.—The works for this purpose, at the foot of Forty-first Street, New York, are at last in successful operation. They occupy a lot 2,000 feet square, and consist of retort-houses, engine-rooms, store-house and office, air-pumps for compressing gas in cylinders, and a gas-holder of 26,000 cubic feet capacity.

In the accounts heretofore published by the inventors of this process in the French journals, and copied in the English and American ones, an incorrect account has been given of its operation. The following is, however, the accurate description, as we learn from the *American Artizan*:—

“The essential or characteristic portions of the process are carried on by the aid of brick furnaces, of which only one was in operation at the time of our visit, several others being, however, rapidly put up and fitted for use. Each furnace has its fire-box so arranged as not only to heat the retort which holds the manganate of soda (the vehicle through which the process is carried on), but also one or more chambers through which an air-blast passes to the retort. The retort, furthermore, communicates, by a pipe furnished with stop-cocks, with a suitable steam boiler. The process is carried on as follows:—About 600 pounds of manganate of soda are placed in the retort, heated to the requisite degree in the furnace; superheated steam from the boiler is then admitted for about ten minutes. Two equivalents of the manganate of soda and two of water react upon each other, as indicated by the formula:



In other words, the water combines with the soda of the manganate to form a hydrate of soda. The manganic acid is changed to sesquioxide of manganese, containing only half the proportion of oxygen, and the other half of the latter passes off in a free condition. At the conclusion of this part of the process, the steam is shut off, and the superheated air is admitted for about fifteen minutes, whereupon the sesquioxide combines with more oxygen from the air, and is converted back into its original form of manganic acid, which, of course, resumes its former relation to the soda,

reconstituting manganate of soda, ready for a repetition of the process. In forcing the air to the apparatus, a steam pumping-engine is used, noticeable for the manner in which friction gearing is applied to transmit power from the engine to the air-forcing pumps, without the jar incident to the use of cogged wheels. The air-blast passes first through cylindrical vessels containing caustic soda, by which its carbonic acid is removed, and thence through the super-heating chamber previously mentioned, to the retort. The retort is never opened, as the material shows no signs of deterioration by use. That in the retort at the time of our visit was tested continuously for six months before being brought to this country, and has been in constant use for six weeks past, the period during which the works have been in constant operation. As the oxygen leaves the retort it passes through a suitable meter, which registers the quantity, and thence to the gasometer, which, at the present time, contains 25,000 feet of oxygen gas, much purer than is required for most of the purposes for which it is to be employed."

The retorts in each furnace are charged with 700 pounds of permanganate of soda, and by the consumption of 2 chaldrons of coke, and with the labor of 3 men, 25,000 cubic feet of oxygen is made per day; and as only a portion of this amount can, as yet, be disposed of, a vast quantity is blown off into the air. It is stated, that at a price of 2 cents per cubic foot, a good margin would be left for profit, were the demand sufficient to utilize the capacity of the works; but the present selling price is 5 cents per cubic foot, compressed in reservoirs up to a pressure of 250 pounds per square inch.

We employed a quantity of this gas for some experiments lately, and found it of excellent quality. It is already, we hear, in use to light up shop-windows in several places in New York, and we hope soon to record its application on one of our great coal-carrying railroads, on a very extensive scale. The experiments in that direction having been very satisfactory.

Photographs of Nobert's Bands.—In *Silliman's Journal* we have a paper by Dr. Woodward, who has so distinguished himself by his micro-photographic results, describing his success in photographing a new plate by Nobert, containing 19 bands with a $\frac{1}{16}$ objective, by Powel & Leland. No lens, previously, had been able to resolve the lines in these bands beyond the 15th.

Photographing Without a Lens, or the method adopted by

Mr. James Thomson, of Glasgow, to photograph the bodily organs of fossil corals. Each of these fossil corals is nearly as large as a hen's egg, and Mr. Thomson, it will be remembered, cut a thin slice out of the centre of each coral, and then ground down and polished the stone slice till it became thin and translucent enough to be used as a negative from which to take photographic prints on paper. When he exhibited these valuable photographs at the British Association at Norwich, last year, Mr. W. H. Harrison recommended him to have them copied in future by the permanent carbon process. Mr. Thomson, in consequence, went to Newcastle-on-Tyne, saw Mr. Joseph W. Swan, the patentee of the chief Carbon process, and made arrangements for a large supply of permanent photographs from the stone negatives. Some of these carbon prints were exhibited at Exeter, and met with much approval. Mr. Thomson says that he and Mr. Swan are now trying experiments upon a new process, which they hope will result in the production of blocks from the coral sections which can be used in the common printing press, to print from in printing ink.—*Mech. Mag.*

Rocksalt Prisms.—Mr. C. Brooks, F.R.S., narrated to Section A, how he and Mr. Browning, the optician, had tried to make rock-salt prisms for use in a heat spectroscope. Supposing the base of the prism to be parallel to the line of cleavage of the crystal, it was found that in nearly every instance the apex of prism split off, and that, as a rule, long before the apex had been ground down to anything like a sharp edge. They therefore thought they would try the influence of annealing upon the crystal, so put one of them in a tin box full enough of sand to well cover the piece of rock-salt, and with a slow and gradual increase of heat, brought it in the course of a few hours to a very high temperature. It was then allowed to cool very slowly indeed. The result of this treatment was to produce pieces of rock-salt which could be ground into prisms without much danger of the splitting of the crystal.—*Mech. Mag.*

Selective Reflection.—During the visit of the British Association to Exeter, several novelties of interest relating to light and optics were brought under the notice of the members. One of the principal of the discoveries was made known by Prof. Gustav Magnus, who found out, by experiment, that fluorspar reflects the waves of ether thrown off by hot rock-salt more than any other polished surface out of the very large list of substances which he tried. Hence, if these long waves were visible to the eye, fluor-

spar would sparkle more brilliantly in such rays than would the polished surfaces of metals. Dr. Balfour Stewart, who was on the platform of Section A during the reading of the paper, called attention to some experiments of his own made a few years ago, tending to prove that the heat rays emitted by rocksalt are very long ones, belonging almost to the extremity of the spectrum. He also found out that, despite the general transparency of rocksalt to obscure heat, it shows great opacity to the heat rays emitted by a second piece of its own substance.—*Mech. Mag.*

In Repeating Tyndall's Experiments on the action of light on vapors, M. Morren found out that even the purest sulphuric acid, quite free from arsenic and other foreign substances, liberates traces of sulphurous acid gas, and thereby causes the formation of a cloud. This fact shows that, in some cases, this method of experimenting is a very delicate test for the presence of certain chemical substances. Moreover, the discovery made by M. Morren affects a large number of the experiments on the action of gases upon radiant heat made by Prof. Tyndall, and published by him in his celebrated work, *Heat Considered as a Mode of Motion*. In all those experiments Dr. Tyndall dried his gases by means of powdered glass and sulphuric acid, so that, as shown by M. Morren, traces of sulphurous acid gas must always have been present in his experimental tube, and influencing the result to a certain extent.—*Mech. Mag.*

Electrolytic Iron.—Dr. Jacobi read a paper before the British Association on the electro-deposit of iron. The learned Professor illustrated his remarks by a series of plates of extreme beauty. The solution from which the metallic iron was deposited consisted of a double salt, the sulphate of iron, and magnesia. It was found desirable to coat the recipient of the deposit with a thin film of nickel or copper. Specimens illustrating the application of the electro-deposit of iron to purposes of engraving (aided by photography) were also exhibited.—*Mech. Mag.*

Meteors.—Prof. Newton, a distinguished American astronomer, in the course of a speech made at the British Association, said that observations of meteors made in the United States tended to prove that the November meteors burnt up at a much higher altitude in the air than the August meteors. He therefore raised the question whether the resisting medium in space which transmits waves of light may not have retarded the lighter fragments forming the

meteoric showers more than it retarded the heavy substances. If so, it might be possible that the lighter fragments were formed of different chemical substances to the heavier ones, and so burnt up at a higher altitude in consequence. He broached this question, he said, merely as a passing idea, and not as possessing any great weight. Perhaps the spectroscope may hereafter give some information upon the point.—*Mech. Mag.*

Duration of Electric Discharges.—In the last number of *Silliman's Journal*, we notice an admirable paper by Prof. O. N. Rood on the above subject. His apparatus, in general arrangement, resembled that used by Wheatstone in his remarkable experiments for determining the velocity of electric conduction, which were, no doubt, the basis of all similar processes for the measurement of extremely small intervals of time, which have been since devised.

The improvements introduced by Prof. Rood consist chiefly in throwing the image of the spark elongated by the rotating mirror by means of a lens on a plate of ground or polished glass, and viewing it with a magnifying lens.

There were, beside, various ingenious devices in the details of structure and arrangement such as have distinguished other investigations of this eminent physicist. As a result of various experiments, Prof. Rood finds, in the first place, that the discharge from a Leyden jar charged by an induction coil, is composed of three parts or successive acts—a white flash, a brownish-yellow gleam, and a fainter and more lasting glow, which, with brass electrodes, is green, and, with platina, grey in color. The duration of the entire phenomena is from $\cdot 000017$ to $\cdot 000050$ seconds—i. e., 17 to 50 millionths of a second. The duration of the white and yellow light together, 6 to 8 millionths, and the duration of the white flash less than 24 hundred millionths of a second.

On the "Meteoric Shower" of the Total Eclipse of August 7, 1869, by Prof. Alfred M. Mayer. In the reports of Professors Morton and Himes on the Solar Eclipse of August 7, there appear remarks in reference to the appearance on the camera plate, of the telescope at Ottumwa, of bright points traversing the field of view. Other unofficial accounts, given in the *Journal*, refer to the phenomenon observed at other stations.

During the month of September, 1869, I was engaged in running a meridian line for the foundations and piers of the Sayre Obser-

vatory, of which I have charge; and on the afternoon of two days, while taking altitudes of the sun with a theodolite, I observed bright, star-like points rush into the sun's image with about the apparent velocity of shooting-stars. The similitude to a meteoric shower was perfect, even to the *trails* left by many, while others appeared to burn out before they reached the sun's limb.

The display was so *artistic* that I called my assistant's attention to it as a beautiful pictorial illustration of Mayer's theory of the maintenance of the sun's heat.

I immediately referred it to its real cause, viz: the flights of minute insects across the field of view. The supposition was confirmed, on withdrawing my eye from the ocular, by observing clouds of minute flies or midges, with thin iridescent wings, flashing in the light of the sun.

Although more of interest to naturalists than to astronomers I will add that on two evenings of the past week while examining the moon, between the hours of 8 and 11, I have seen birds crossing the moon's image, (which entirely covered the field of view,) at the rate of about 8 in a minute. They were all going eastward.

Errata in Prof. Mayer's Report on the Eclipse of August 7, 1869. (See October number of *Journal*.)

Page 258, line 14 from bottom, for Plate III. read Plate II.

- | | | | |
|--------|------|-----------|---------------------------------|
| " 260, | " 10 | " top, | " <i>four</i> read 41. |
| " " | " 18 | " " | " <i>sideral</i> read sidereal. |
| " 262, | " 16 | " " | " <i>node</i> read mode. |
| " 263, | " 11 | " bottom, | " <i>numbra</i> read umbra. |
| " " | " 7 | " " | " <i>ocular</i> read ocular. |
| " 265, | " 20 | " top, | " 40 read 50. |
| " 266, | " 15 | " " | " 40 read 50. |
| " 274 | " 7 | " " | " <i>were</i> read was. |

On Plate I. *dele* Instantaneous.

On Plate III. for 027 inch read .027 inch.

Spectrum of the Aurora, Zodiacal Light, &c.—In connection with the observations of Prof. Young, during the late eclipse, the following translation from a few paragraphs in the text accompanying Angström's chart of the solar spectrum may be of interest.

On page 42, he says, after some introductory remarks: "In fact, during the winter of 1867-8, I have been able to observe, repeatedly, the spectrum of the luminous arc bordering the obscure segment, and always seen during the feeble auroras. Its light is almost monochromatic, and consists of *a single brilliant ray*, situ-

ated to the left of the well-known group of calcium lines. By measuring the distance from this group, I have determined the wave-length of this ray, which is found equal to $\lambda = 5567$.

Beside this ray, of which the intensity is relatively great, I have observed, also, by widening the slit of the spectroscope, traces of three lines extending almost as far as F.

On a single occasion, when the luminous arc was agitated by undulations which changed its shape, I saw regions momentarily illuminated by certain feeble spectral rays; but, taking into account the intensity of these rays, I would, nevertheless, say that the light of the luminous arc is sensibly monochromatic.

There is a circumstance which gives to this observation of the aurora spectrum a much greater importance, and, indeed, a cosmical character.

During one week of March, 1867, I succeeded in observing this same spectral ray in the zodiacal light which then presented itself with an intensity truly extraordinary for the latitude of Upsal.

Finally, when during a starlight night, all the sky was, in a certain sense, phosphorescent, I found traces of it in the feeble light emitted by all parts of the firmament.

A very notable fact is, that this remarkable ray does not correspond with any of the known rays of simple or compound gases, so far, at least, as I have studied them up to this time.

It follows, from what I have said, that an intense aurora, such as may be seen above the polar circle, would probably give a more complicated spectrum than that which I have found. Granting this, we may hope that an opportunity will be afforded of explaining the origin of the rays already found, and the nature of the phenomenon itself. Not being able to give this explanation at present, I propose to return to it at another time."

Remarkable Aerolite.—Dr. Neumayer recently presented a paper to the Imperial Academy at Berlin, detailing the facts relating to the fall of a meteor a short time ago, at Krähenburg. The fall took place in the day-time, and so great was the velocity of the mass, that it buried itself two feet deep in the sandstone rock. It was dug out while still warm, and found to weigh $31\frac{1}{2}$ pounds. So great was the noise caused by the rushing of the aerolite at planetary velocity through the air, that it unnerved those people who stood near the spot where it fell, and the sound was heard over a radius of thirteen miles.—*Mech. Mag.*

Civil and Mechanical Engineering.

PUMPING ENGINES.

By W. M. HENDERSON, Hydraulic Engineer.

THIS subject has attracted considerable attention in the columns of the *Franklin Institute Journal*, dating from the introductory article on "Cornish Pumping Engines," published in the July number of 1868. Up to the present time, the pre-eminence then claimed for that description of engine has been successfully maintained, if, in forming an opinion, we are to be governed by the fact developed in the course of the discussions following the article in question. Throughout the several papers contributed, it has been generally conceded, that the Cornish Engine must invariably be superior in economy of working, theoretically and practically, to any possible rotative engine for pumping purposes.

Early in the discussion it was intimated that there was yet another engine, based upon reciprocating parts, without a fly-wheel, which possessed the capacity of rivaling the Cornish in its best results, without the requirements of magnitude demanded by that engine. The mere mention of such an engine, however, was all the information that could be gained by subsequent solicitation from the author of that remark. Later articles in reference to the same engine, which have appeared in the columns of the *Journal*, show a reticence in regard to enlightening us, as to the means employed, by which the economical results claimed are to be obtained, or any disposition to describe the principles upon which the said engine is constructed. There should not exist any occasion for this, as truth will be rendered more lucid by investigation, as gold is purified by the searching power of heat in the crucible.

The economical supply of water to large cities is a matter at all times of the utmost importance, and there is a grave responsibility attached to the selection of a pumping engine, when the quantity of water to be raised is counted by the half million gallons of water per hour. We should not be blindly led by theories advanced by interested parties in favor of any particular description of engine, without the exercise of sound, deliberate judgment, based upon the most accurate information to be obtained. Is it reasonable to expect that we shall find this knowledge, peculiar to the mathematician

and educated engineer, whose whole life has been devoted to the study of problems, kindred to this, in a body of politicians and other gentlemen, whose talents do not run in that particular direction? There will always be a certain degree of importance attached to the action of such a body, however, from the dignity of the position occupied, their recent decision to retest the old experiment of low expansion, upon a high scale, has prompted the inquiry as to whether this engine, lately ordered by them, possesses any new features, not before known, whereby the great merit claimed for it in point of economy, has any existence in fact.

In the absence of more authenticated information, we will briefly review the apparent points governing the case, prefacing our remarks with a general outline of the construction of the engines alluded to, as designed for the new water-works now building at West Philadelphia. These engines will be a duplicate pair of Duplex engines, containing in all eight steam cylinders and four pumps, each pair to be composed of two distinct engines, arranged side by side, and calculated to work at right angles, or at quarter-stroke to each other. There is first a high pressure cylinder of 29 inches diameter, to the rear of which is bolted a low pressure cylinder of 50 inches diameter, a single piston rod passing through both is continued into the pump, which is 22 inches diameter, the stroke of all being 4 feet. The latter is situated in front of the high pressure cylinders, with a space between the two, to allow of the working of a double bell crank, in shape of an inverted T, for operating the engine valves, as also the air-pumps; a rock-shaft passes through the head of the T, and motion is communicated to the tail of the same, by a short link, driven from a cross-head pin, secured to the centre of the piston-rod, playing between the stuffing-boxes of the pump and high pressure cylinder; each end of the head of the T, drives a single acting air-pump. These are placed in a pit immediately beneath the bell cranks, the inner ends of the rock-shafts are furnished with crank-arms, from which rods give motion to upper rock-shafts carrying arms for giving the necessary motion to the slide-valves. These rods cross each other, and connect to the upper rock-shafts of the opposite engine, by which means each engine, having the necessary position, works direct the slide-valves of its neighbor, (a motion originally invented by one Jonathan Dickson, about thirty years ago). Each cylinder is provided with a steam chest and slide-valve, operated by a valve-stem common to both,

the high pressure steam-chest is elevated to the level of that upon the low pressure cylinder by strut steam ports, a steam pipe conveys the exhaust steam from the high to the low pressure steam chest, and another the final exhaust from the latter to the condenser, situated in the air-pump pit.

The steam from the boiler follows full stroke in the high pressure cylinder, and is then admitted to the low pressure cylinder, there to act by expansion.

It will be at once apparent, that the high pressure cylinder becomes the measure for expansion, being in fact a cut-off cylinder for the other. Were we to expand the same volume of steam in a single cylinder, having an area equal to the two combined, we would produce a gain of mechanical effect equal to about $11\frac{1}{2}$ per cent. above that obtained by the combination, besides effecting a large saving of exposed condensing surfaces. To render this more plain, let us follow the action of the steam in both cases. In the combined arrangement, the steam acts with a full pressure upon the area of the smaller piston from the commencement to the end of its stroke, at the same time, the charge from the previous stroke is admitted to the low pressure cylinder. But as the steam in expanding within this cylinder, reacts with a back pressure upon the piston of that of the high pressure, seeing that a communication between the two must necessarily be kept open, the effective area of the expansion cylinder will be reduced by the extent of area presented by that cylinder, it will also be observed that as the expansion is going on, the high pressure piston follows it up completely to the end of the stroke, when the whole of the steam will be imprisoned within the larger cylinder. By comparing the relative capacities of these two cylinders, we shall find that the steam will have been expanded three times, corresponding to cutting-off at one-fourth stroke, in a single cylinder, whose area is equal to the aggregate of the two. As the case stands, the single cylinder will have a gain of mechanical effect over its rival equal, as before stated, to about $11\frac{1}{2}$ per cent. On the other hand, the compound engine will have performed its work with a marked regularity of motion, consequent upon a more uniform distribution of the force employed, as made known to us by Woolf about the beginning of the present century. Economy in the results is what we are after, however. An engine working without any expansion will undoubtedly work more steadily than either of them, but economy

will be exactly in proportion to the number of times the steam is expanded. When steam is admitted throughout the whole stroke, its efficiency is, of course, equal to that of unity, when cut off at one-third the effect will be as 1 is to 2.099, at one-sixth as 1 is to 2.792, at one-tenth as 1 is to 3.3.

Again, the propriety of using two cylinders, when one can be made to answer, is open to serious objections, not the least of which are increased frictional, and condensing surfaces, sources for loss of power, which all intelligent engineers are fully alive to. But for these, and other inherent objections, afterwards to be noticed, we probably have the reason why the engine gained no notoriety in England, the country where its essential features were fully developed. There are cases where the compound principle may be used with advantage; as, for instance, where a very high degree of expansion is required, too great to be safely employed in a single cylinder, owing to the blow which would be given to the piston by the introduction of highly compressed steam when cutting off at an extremely early part of the stroke. In such a case the principle is clearly admissable, for the steam has then two cylinders to expand through, and the cutting-off point in the first one need not exceed that which has been found safe in practice.

Within ordinary limits the Cornish beam engine will be found to answer all requirements, as a very large proportion of the initial force is absorbed in overcoming the inertia of the heavy beam, which thus becomes a reservoir of surplus force, to be given out during the latter part of the stroke when the steam is attenuated by expansion, the result is that a comparatively steady velocity is maintained throughout, much to the advantage of the engine, as well as to the operation of the pump. The whole secret of successful working lies in the proportioning of the gravity of the moving mass, in accordance with the degree of expansion employed. As an instance pointing conclusively to the importance attached to this matter, I would state a case where two large expansive engines, of nearly the same size, working near each other, one of which had an open net work beam weighing about 30 tons, the other a strong heavy beam of 45 tons weight, the difference of the working of the two was very perceptible, while the duty performed by that possessing the heavy beam was nearly five million pounds greater than the other.

Returning to the subject of compound engines, we are reminded

of an argument advanced by some, that the great economy attending their use, has been found to proceed from the fact of the steam being used twice over. In answer to this remarkable statement, I would simply add, that the feat of expending a dollar, and still retaining it, has never yet been successfully accomplished. Any person possessed with sufficient intelligence to comprehend the nature of the case, must be at once impressed with the fact that a duplication of frictional resistance, and extension of condensing surfaces, should never be resorted to, without some special object, and a clear proof that the adopted evils will be counterbalanced by a greater gain accruing from the innovation itself. And this gain must be one of economy, not economy of first cost, but of fuel, which is the true standard by which the worth of any such machine must ultimately be estimated. The true expense of an engine is the original price, added to its annual cost, capitalized say at twenty years purchase. To make the most out of the fuel then becomes our imperative duty, and this, it has been decided, can only be done by using the steam with as high a degree of expansion as can be safely obtained. The expanding of steam three times is not such an extreme case, as to require two cylinders to accomplish it. On the contrary, it is far short of the limit to which the principle has been extended in the single cylinder of the Cornish Engine. Many of these work regularly cutting off at one-sixth of the stroke, and that, too, with the attraction of gravity acting in their favor, by doing actual work, instead of grinding along an endless plane of horizontal obstacles.*

It may be argued that the rate of expansion is not limited to cutting off at one-third of the stroke, as in this case, but may be extended to any point, by increasing the initial pressure of the steam, together with the diameter of the low pressure cylinder. This manner of testing the expansive principle of steam, by increasing the area instead of the length of the cylinder, as has been heretofore the practice, possesses at least the merit of novelty. There is one objection to it, however, of rather a serious nature, and that is the great loss sustained by condensation, which will occur at the moment the steam passes from the high to the low pressure cylinder.

* In one case where a duty was recorded of 128,000,000 of pounds of water, raised one foot high by the consumption of 112 pounds of coal, the steam was cut off about one-tenth or one-twelfth of the stroke, while in Woolf's combined cylinder engines, the steam has been expanded as high as twenty times.

Here, it is manifest, a very sudden expansion takes place, by the steam having to diffuse itself over a greatly increased area. In the present case this area is three times greater than that which confined the steam an instant before. Steam, expanding in this manner, is always accompanied by a fall of temperature due to the disappearance of heat in overcoming the cohesion of the vapor particles, producing liquefaction, and this will be continued to the end of the stroke, partly from the abstraction and conduction of heat by the metal of the cylinder itself, assuming temperatures intermediate between those of the steam at the beginning, and at the end of expansion, as well as from the effect due to the expansion of the steam, in doing the work of driving the piston.

The quantity of steam liquefied at the early part of the stroke, from the cause stated, may be greater than that due to the expansive working of the piston, especially as each end of the cylinder has become thoroughly chilled from contact with the frigorific influence of the condenser, just before the charge of steam is let in from the cut-off cylinder.

It is plain any increase of diameter of the low pressure cylinder, for the purposes mentioned, but increases the evil pro-ratio as the square, and that any considerable change in the relative diameters of the two cylinders, will seriously affect the one prominent feature possessed, *i. e.*, the uniformity of present effect.

Besides this internal condensation, there is yet to be added that produced by the increased surface exposed to external condensation, two cylinders in place of one, with an extra steam chest, strut steam ports, and a long steam pipe for conveying the steam from the extreme end of one cylinder to the other. This excess of external condensing surfaces, it is estimated, will be about 40 per cent. above that of the single cylinder arrangement. What the sum total of these losses will amount to it would be difficult to determine, but that they are of a ruinous nature is very apparent, and must consume a considerable amount of coal to be maintained.

While upon this subject, I would like to draw attention to a statement made by Mr. Lean, in his report, upon the engines in Cornwall, compiled at the request of the British Association for the Advancement of Science. "The duty of the best pumping engines in Cornwall far exceeds what could be effected, were it even possible to apply the force of the steam immediately to the water, unincumbered by the friction and imperfection of machinery, or the

loss arising from accidental condensation." This remarkable statement is perfectly valid, when we bring forward the great gain derived from the expansion of the steam in the Cornish Engine. Supposing that the force of the steam could be applied directly to the water in the suction pipe, that there shall be no loss by condensation, and a perfect vacuum maintained above the column of water to be lifted, then allowing that 112 pounds of coal will convert 15 cubic feet of water into steam of 50 pounds pressure to the square inch, which is equal to an evaporation of 8·37 pounds of water per pound of coal (the best Welsh coal will evaporate 9·5 pounds). At this pressure the volume of steam, compared to that of the water, from which it is generated, is 435 times greater. Then $15 \times 435 = 6525$ cubic feet of steam $\times 144$ square inches, and by 50 pounds pressure $= 47,000,000$, about one-half only of the duty performed by the best engines in Cornwall, as will be seen by referring to the figures below.

By the advantages offered in the expansive principle of steam, we are enabled to overcome all the defects incurred from friction, and imperfection of the machinery, together with the losses arising from the accidental leakage of the valves and connections, with the attending condensation, and still double upon the theoretical effect that would be produced by using steam non-expansively.

Tabular Duty of Cornish Pumping Engines.

Fowey Consuls	50 inch.....	130·2 M.
Holmbush	80 "	122·4 M.
East London Water-works		105·7 M.

The average duty of the whole year 1855, as given in Brown's report:—

Austin's.....	80-inch.....	at Fowey Consuls.....	98·6 M.
Treffry's.....	"	at Par Consuls.....	98·5 M.
Darlington's.....	"	at Great Polgooth.....	93·9 M.

The highest duty ever recorded for any continuous period has been awarded to Taylor's 80-inch at the United Mines in Gwennap, viz: 128 M.

The average duty of fifteen engines at the Cornish Mines, taken monthly for a whole year, was 70 M., which is also the average duty of the best Cornish Engines belonging to the London Water-works. I would here reiterate a statement made at the conclusion

of my previous article on "Cornish Pumping Engines," that any improvement, looking to further economy, above that afforded by that class, may be found in the possible adaptation of the compound principle, applied to the Cornish type. At some future day, I may call attention to the design of such an engine, should my daily labors permit.

The above list of the duty performed by the Cornish Engines referred to, is respectfully offered as a matter for comparison in the forthcoming test of this other engine, based upon reciprocating parts, without a fly-wheel, which, it is claimed, has the capacity of rivaling the Cornish in its best results.

Philadelphia Hydraulic Works, Oct. 1st, 1869.

Casting Cylinders for Pneumatic Piles to be used in the Omaha and Leavenworth Bridges. In a letter just received from Mr. Robert Cartwright, of the Boomer Bridge Works, Chicago, he says as follows:—

"We have made 132 piles in all, and have only lost two during the time. Yesterday we made the 101st perfect cylinder *consecutively*, one each working day. The cylinders are $1\frac{1}{2}$ inch thick, 8 feet 6 inches diameter and 10 feet long. By the process, it is simply impossible to have them of unequal thickness. In the arrangement of the moulds, I am enabled to cast them without having to replace the brick of mould. By simply putting on fresh loam on the brick mould (which is well vented) I get a smooth exterior, the cylinder generally coming out of the mould and leaving it as perfect as before iron was poured in. The core barrel is usually all drawn out in an hour after the casting is poured. We cast at 5 P. M. and lift cylinder out at 7 A. M. next morning. We make them without *sinking head* and have no trouble in getting them perfect. By means of a shaft and tunnel to moulds, the casting is cooled rapidly, and the core being removed so soon, the strain resulting from *shrink* is entirely obviated, none of them ever having shown the least sign of a crack, or an alteration of shape from a perfect circle. The greatest variation of diameter we ever had was $\frac{3}{8}$ inch, and that was during the first products of the moulds, until we got the right allowance for ferro-static pressure."

This letter was accompanied by several very interesting photographs, one showing a train of twelve long cars each carrying one of these tubes, and reaching from the foreground into the dim distance.

BELTING FACTS AND FIGURES.

By J. H. COOPER.

(Continued from page 239.)

Paper Belting.

THE Messrs. Crane Bros., of Westfield, Mass., who manufacture Crane's Patent Paper Belting, have kindly furnished me with the following facts concerning their new fabric for driving belts. "Our belts are manufactured from pure linen stock, and can be made of any desired thickness, width and length; we guarantee equal driving power from equal surface, as from leather or gum, and we recommend them only for straight and unshifted belts, making none less than five inches wide. They will not stretch nor change shape, and being made all in one piece, of even thickness, will run smoothly and straight. We have proved them equal in durability with leather, and equal also in strength, where they have been arranged for one to pull against the other. They adhere to the pulleys very closely, and generate no electricity while running. They are quite flexible, and do not crack in passing over pulleys even as small as six inches in diameter. They are not affected by heat at ordinary temperatures, nor by dust or oil, but will not run in water; being very tough, they would answer a good purpose for elevator belts, holding the bolts well and running in a direct line without swinging from side to side.

"Compounds similar to those used for stuffing leather belts, or black lead, mixed with sperm oil, are very good to apply to our belts, when dry and slipping.

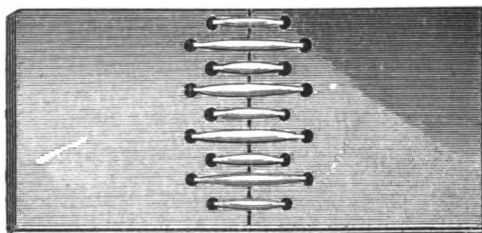
"For *endless* and for *heavy belts*, our belting material is not to be surpassed, and when fitted to the pulleys at the proper length, it must remain so until worn out. It is 40 per cent. cheaper than leather, and for all heavy and expensive belts must come into general use."

Directions for Lacing Paper Belting.

"For narrow belts butt the two ends together, make two rows of holes in each end (thus obtaining a double hold), and lace with lacing leather, as here shown.

"For wide belts, where extra strength is required, rivet pieces equal in length to width of belt on back of each end, and make the connection with lacing, as before. This belting should, in all cases,

be put on by the use of clamps, secured firmly to each end of the belt, and drawn together by bolts running parallel with and outside the edge of the belt, making no allowance for stretch.



Wide belts, in dry places, can best be connected with Wilson's Belt Hooks, riveting down the teeth, thus making a connection that will not wear out."

We present some facts derived from testimonials furnished to the makers of the paper belting.

One party says the 15-inch paper belt gives us entire satisfaction; it drives all our machinery with perfect ease; runs very straight, without any swaying or sagging; is not affected by temperature; and there are no indications of electricity, which we consider a great gain.

Another party have a 15-inch belt, 70 feet long, in use during 15 months; the surface next to pulley is hardly marked, and shows no indications of wear; belt not touched, since first put on, for repairs of any kind.

Another party says: "We have been using one of your 14-inch Paper Belts for the last 4 months to drive a paper engine, which requires about 13 horse-power. It works to our entire satisfaction, and gives us less trouble than any other belt in the mill."

Another party has in use a paper belt 12 inches wide, 50 feet long, and runs from the fly-wheel of a 25 horse-power engine to a pulley on line shaft, driving machinery which nearly exhausts the power of the engine. It gives equal satisfaction with a leather belt formerly used in same place. A narrower and shorter belt, crossed also, has done quite as well as a leather belt under like circumstances.

Another party have thoroughly tested the paper belt, and are entirely satisfied therewith. The belts are 12 inches wide; one 120 feet long, the other 92 feet; they do not stretch or slip.

Another party says: "The Paper Belt continues to give good

satisfaction; it has already been at work on our engine as long as the majority of leather belts last in the same place, and as yet we can see no signs of wear. It does not stretch nor slip, and running in the open air, as it does, it saves us a great deal of trouble which we have had heretofore with a leather belt. Having had a great deal of experience, we do not hesitate in saying that the Paper is a superior Belt."

Belts and Pulleys.

"We would not venture to prophesy that belts will continue for ever in general use, especially if made of leather, in the old way. Nor is our faith in the perpetuity of small pulleys very resolute. Robertson's frictional gearing seems to work more steadily than belts; but if pulleys are large, the friction of their faces against each other is sufficient for most work, and they will run with less power than belts or Robertson's gearing. To make pulleys work well against each other, they must be turned with more truth than is usual; and the shafting must be better lined; and there must be something elastic in the journal-boxes, such as a little rubber, to press the pulleys together.

"The vibration or chattering of lathes is probably due to the spring of the belts, more than to the spring of the metal of the lathes. So far as this is the case, the frictional gearing, of either kind, will get rid of it.

"In driving fans there is frequent trouble with belts, and there is more expense than need be; and the noise and vibration are evidences of serious imperfection, which, perhaps, is unavoidable when a soft material is used that cannot have an exact shape.

"A friend of ours proposes to use steel belts for certain cases, such as fans. The steel must be welded perfectly, and must be of mild quality, and the pulleys must be large, to make them work well. Steel belts would run with less power than leather, because the power exerted in bending them would be restored when they straightened themselves; but leather does not return much of the power required to bend it around the pulley." * * * *Amer. Artizan*, Aug. 2, '65, p. 201.

Leather Belts.

"A friend of ours who has had experience in tanning leather for belts, and has conversed about belts with many machinists, and is familiar with their experience, assures us that the adhesion of belts

is much better when the hair side is against the pulleys, and that the belt used in this way is more durable. The belt will not crack on the flesh side so readily as on the hair side, and seldom cracks at all, if the hair side is against the pulley. He has known cases in which belts slipped and would not do the work required of them when the flesh side was against the pulley; but when they were turned hair side to the pulleys they ceased to slip, and did much more work than they could do with the flesh side to the pulleys. His theory is, that the belt, as well as the pulley, adheres best when smooth, and the hair side adheres best because it is smoothest."—*Am. Artizan*, Aug. 16, '65, p. 234.

Belts.

"The effective radius of a pulley is equal to the radius of the pulley added to one-half the thickness of the belt.

"In ordinary cases a belt will last about three years.

"Leather belts must be well protected against water, and even moisture.

"India rubber is the proper substance for belts exposed to the weather, as it does not absorb moisture and stretch and decay.

"It is quite probable that these belts will increase in popularity among manufacturers.

"In joining the ends of a belt, it is generally considered best to cut small holes through the ends and lace them with a leather strap.

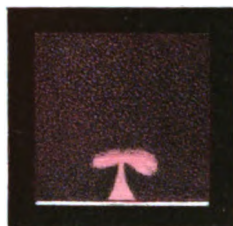
"It is found, in practice, that belts should not be subjected to a strain of over 300 pounds per square inch of section.

"Good belting of $\frac{3}{8}$ inches thick will sustain a strain of 50 pounds per inch width without risk, and without serious wear, for a considerable time."—*Am. Artizan*, July 1, '68, p. 394.

(To be continued.)

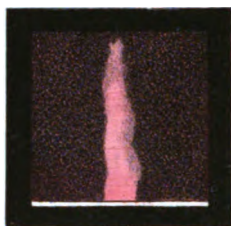
Plumbago as a Lubricant.—Every one knows that for heavy machinery plumbago is a good lubricant, but every one does not always think of applying it where it would serve best. It may thus be of value to some of our readers to know that Mr. Thomas Shaw found that a planer whose bed-plate required the force of eight men to slide it when lubricated with the best ordinary material, could be easily shifted with one hand when plumbago of good quality was applied.

Fig. 1.



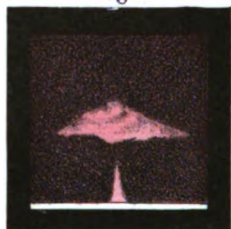
July 1. 8^h 20^m
S. W. Limb
Height=38"

Fig. 2.



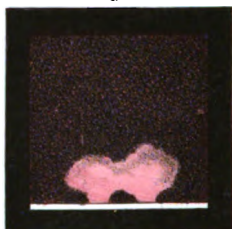
July 1. 3^h 45^m
N. E. Limb
Height=120"

Fig. 4.



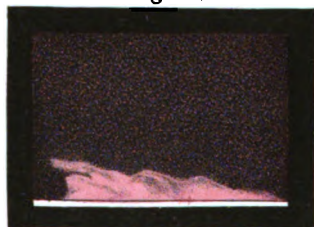
July 2^d 11^h 55^m
Position angle 278°
Height=65"

Fig. 5.



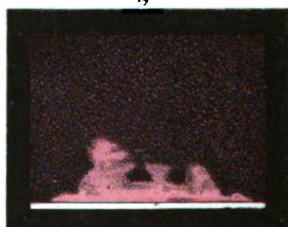
July 4. 9^h 0^m
S. E. Limb
Height=40"

Fig. 7.



July 4. 5^h 30^m
E. S. E. Limb
Height=25"

Fig. 8.



July 4. 5^h 45^m
N. E. Limb
Height=40"

Mechanics, Physics, and Chemistry.

OBSERVATIONS OF THE SOLAR PROTUBERANCES.

BY PROF. F. ZÖLLNER.

From the Report of the Royal Saxon Academy of Sciences. Translated from the *Astronomische Nachrichten*, No. 1769. August, 1869, by Alfred M. Mayer, Ph. D.

WITH my method (communicated to the Royal Society of Sciences, at Leipsic, at the session of the mathematical and physical class of the 6th Feb.), which I have been unable to apply until now, on account of the incomplete arrangement of instruments, I have just observed protuberances with *great sharpness and clearness*. Their shape and general character is approximately represented in the accompanying drawings.

From the nature of the method, the *same* protuberance was simultaneously observed in three different colors, corresponding to the three homogeneous lines of its spectrum. There is, however, a material difference between the red and blue image on the one hand, and the yellow on the other. The latter is very intense only in close proximity to the edge of the sun's disc, and in this respect corresponds to the other images, while the more delicate details disappear at a greater distance. This difference does not seem to be caused by the greater brightness of the spectrum in that region, but appears to depend on one of the two following hypotheses for an explanation:—

Either that the rays which give rise to the yellow image emanate from a gas having a greater specific gravity than hydrogen, and therefore existing at a lower level,

Or, that the greater intensities of temperature and pressure nearer the surface of the sun cause hydrogen to emit these rays.

The first protuberance which I observed, is represented by Fig. 1. Above an intensely luminous peak-shaped mass, rising from the border of the sun, is spread a cloud-like formation of less intensity. To the same type belong the protuberances of Fig. 4 and Fig. 9. In Fig. 4 it was remarkable that the surprisingly beautiful cumulus-shape of the cloud was separated from the peak by a considerable distance. The cloud was exceedingly delicate, and even its

finest details could be recognized. The separate cumuli of which it was composed, appeared almost like dull luminous points.

One of the most remarkable formations was the second of the protuberances represented in Fig. 2. I hardly believed my eyes when I noticed in it the tongue-like motion of a flame. This motion was slower, however, compared with the size of the flame, than that of high, towering flames at great conflagrations. The time required by such a wave in passing from the base to the apex, was about 2 or 3 seconds. I endeavored on the following days to verify this observation by the discovery of similar formations, but I have not succeeded, in spite of my arduous and continued search. I therefore request that this statement may be considered as one requiring further proof.

Surprising examples of the great rapidity with which the protuberances change their form and intensity of light, are found in Figs. 3, 6 and 10. In these Figs. the different shapes are represented, which the same protuberance assumed after the intervals of Leipsic mean time stated under them. The heights mentioned beneath, in seconds, refer to the highest point of the protuberance.

The protuberance represented in Figs. 3 and 4 were observed simultaneously with Mr. Vogel, Assistant of the Leipsic Observatory, and our drawings have been found to agree.

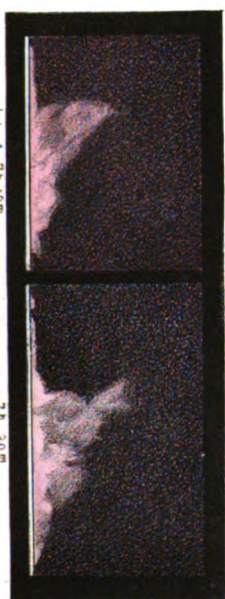
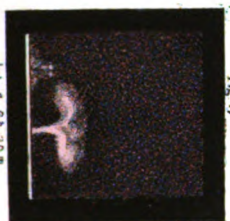
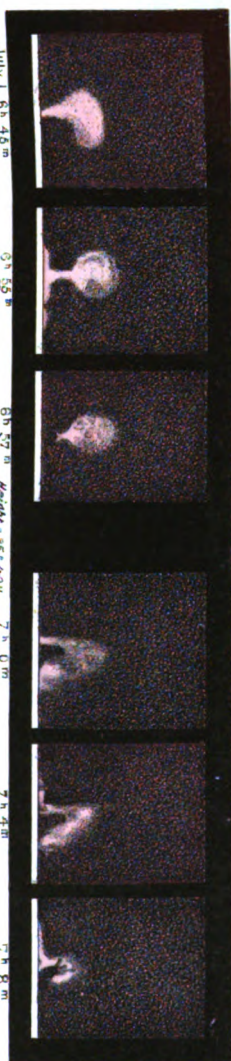
If I may be allowed to compare the general impression of the protuberances, observed by me so far, with terrestrial phenomena, I will state that the great majority remind me of the different forms of our clouds and fog. The cumulus type is completely developed in the above mentioned cases. Other formations remind us of masses of clouds and fogs floating closely over lowlands and seas, whose upper parts are driven and torn by currents of air, and which present the well known ever-varying forms when viewed from the tops of high mountains.

All who have hitherto observed the protuberances through my instrument, agree in all material points with my comparisons concerning their general character.

An exception is seen in the flame-like protuberance of Fig. 2. On looking at Figs. 1, 3, 4, 9, and perhaps 5, the observer will unconsciously consider the part steeply rising from the border of the sun as the cause of the cloud above it. He is reminded of volcanic eruptions and thermal springs.

As far as clearness in the contrast of the image with the back-

Fig. 3.
Position angle of the protuberance 76°.



ground is concerned, the method gives entire satisfaction. Even when the sun is but a few degrees in altitude, the outlines and details appear with a clearness which surprised all observers.

I am at present engaged in modifying this method so that the image situate in the blue portion of the spectrum can be photographed directly and thus multiplied.

If large prisms of considerable dispersive power could be procured, and an excellent clock-work connected with the instrument, the image of the sun could be diaphragmed off and a circular slit used in the spectroscope. We would then be enabled to observe *simultaneously* all the protuberances on the limb of the sun, in the different parts of the spectrum, just as in a total solar eclipse of long duration.

Finally, I beg to make known an observation, which appears too remarkable to remain unmentioned, and which will be of great importance in extending our knowledge of the actions going on near the surface of the sun, if its explanation be found correct.

As early as the 27th of June, the first clear day after a long spell of cloudy weather, I observed the bright protuberance-lines without, however, being able on that day to make a complete observation of these formations. As soon as I approached the slit of the spectroscope to a certain position on the sun's limb, where the protuberance lines appeared particularly long and bright, bright linear flashes passed through the whole length of the dull spectrum *over* the limb of the sun, about 3 or 4 minutes distant from the latter. These flashes passed over the whole of the spectrum in the field of view, and became so intense at a certain point of the sun's limb as to produce the impression of a series of electrical discharges, rapidly succeeding one another, and passing through the whole of the spectrum in straight lines.

Mr. Vogel, who afterwards, for a short time, took part in these observations, found the same phenomenon at a different portion of the sun's limb, where protuberance lines also appeared.

This phenomenon can be explained by the hypothesis that small, intensely incandescent bodies moving near the surface of the sun, emit rays of all degrees of refrangibility, and produce flashes of a thread-like spectrum as their image passes before the slit of the spectroscope.

Leipsic, July, 1869.

ANALYSIS OF THE NATIVE PHOSPHATE OF LEAD FROM CHESTER COUNTY, PA.

BY CHARLES P. WILLIAMS.

THOUGH the lead-bearing veins near the line of junction of the mesozoic sandstone with gneiss, in Schuylkill and Charlestown townships, Chester County, have enriched mineralogical cabinets with many most remarkably beautiful specimens of pyromorphite, nothing has been published with reference to their chemical composition. The elaborate investigations of Prof. J. Lawrence Smith,* though extending through all the other species from the locality, fall short, I believe, from recording any analysis of the phosphates abounding thereat. It seems, of all American minerals, to have been the most neglected at the hands of chemists.

In 1863 the writer came in possession of a remarkably fine suite of the species from both the "Wheatley" and the "Chester County Mines," which had been collected by Joseph Cocking, who had been successively mining captain at both these works, and subsequently tributer at the latter. I have from time to time analyzed some of the specimens of pyromorphite, according to the following method:

The solution of the mineral was effected in nitric acid and the lead precipitated in the greatly diluted solution by means of a long continued current of sulphydric acid gas. The precipitate thus formed (after digestion with sulphide of ammonium to remove sulphide of arsenic if present), was converted into sulphate of lead and weighed as such. The solution in sulphide of ammonium was, after proper preparation, invariably examined for arsenic, but only in one instance was even a trace obtained of this metal.

The filtrate from the sulphide of lead was boiled for some time with the addition of nitric acid, the concentrated liquid neutralized with ammonia, acetic acid added and the whole boiled till the odor of acetic acid was no longer strongly noticeable. The precipitation of the ferric phosphate and of the fluoride of calcium was thus effected. The precipitate was weighed, fused with carbonate of soda, extracted with water, chloride calcium added to the aqueous solution, the precipitate separated, treated with acetic acid and the resulting fluoride of calcium weighed as such. This weight being deducted from the joint weight of the original precipitate gave the ferric phosphate, the composition of which was determined by dissolving the residue

* *Amer. Jour. Sci.*, II., XX., 245.

from the aqueous solution of the fused precipitate, in hydrochloric acid, adding citric acid, and precipitating the iron as sulphide by means of sulphide of ammonium. The sulphide of iron, converted into ferric oxide and weighed, and the weight deducted from the weight of the original precipitate minus the fluoride of calcium, gave by difference the amount of phosphoric acid carried down in combination with the oxide of iron. In the calculation of the final result the ferric oxide was, of course, reduced to its equivalent in ferrous oxide. To obtain satisfactory results at this stage of the operation, it was found that an amount of mineral of not less than three grammes weight was required to be taken. This, of course, gave troublesome amounts of precipitates in the previous and succeeding stages, and the results therein obtained were usually controlled by operations on smaller quantities in which the precipitates by ammonia and acetic acid were simply separated and weighed without any attempt at their analysis.

From the filtrate from the above, the lime was first removed as an oxalate, in an acetic acid solution, by means of oxalate of ammonia, and the phosphoric acid then precipitated by the ordinary magnesian mixture. The precipitates of phosphate of ammonio-magnesia were always redissolved and reprecipitated by ammonia. To the amount of the phosphoric acid thus obtained was added the small amount of phosphoric acid obtained by the difference in the separation of the constituents of the precipitate by ammonia and acetic acid.

The chlorine was estimated in a separate portion of the original mineral. In calculating the results for a rational expression of the analysis, the amount of lead required for the chlorine, being expressed in terms of oxide, was deducted from the total oxide of lead (calculated from the sulphate) and the remainder of the oxide was taken as tribasic phosphate. The ferrous oxide was also assumed as existing in the same condition and the joint quantities of phosphoric acid required for these bases, deducted from the total obtained phosphoric acid, gave a remainder from which was calculated the phosphate of lime (3 CaO PO_3). In all my analyses the theoretical amount of lime thus required (independent, of course, of that in combination with the fluorine which was directly determined) was less than that actually obtained. In the case of analysis No. 1 this discrepancy is the greatest, amounting to 0.21 per cent. Is it that the oxide of iron does not exist as a phosphate or does the ex-

cess of lime result from the presence of some calcarous mineral associated with the pyromorphite? The discrepancies in the amounts of lime have been disregarded in the table of results below given.

The following three analyses are of specimens from the "Chester County" Vein and represent the three most common shades of the mineral from this locality. No. I. was of dark olive-green color, No. II. was of a yellowish-green shade, and No. III. approximated more closely to II. than to I., though still darker than the former. The analyses are of the mineral dried at 212° Fahr.

	No. I.	No. II.	No. III.
Phosphate Lead (3 PbO PO ₃).....	87.40	85.89	87.01
Phosphate Lime (3 CaO PO ₃).....	.37	2.64	Trace (?)
Ferrous Phosphate (3 FeO PO ₃).....	1.74	.62	1.39
Chloride Lead (Pb Cl).....	9.79	9.41	9.13
Fluoride Calcium (Ca F).....	.84	.67	.91
Arseniate Lead.....	None.	Trace.	None.
Matter insoluble in Acid.....	.42	Trace.	Trace.
	100.06	99.23	98.44*
[Excess of Lime.....]	.21	.11	.15]

* In analysis No. III. there was a trifling loss of PO₃.

By operating on 29.167 grammes of pyromorphite from the same locality, and carefully conducting the cupellation of the button of lead obtained, I obtained a button of silver weighing .0011 grammes, equivalent to .0037 per cent. metallic silver, probably existing as chloride and as such replacing some of the chloride of lead. This amount (equivalent to 1 $\frac{1}{8}$ oz. of silver to the ton, of 2,000 pounds, of similar ore) falls considerably below that obtained in the practical working of the so-called phosphate ore from this mine, but as this ore, as sold to the smelting works, was largely intermixed with galena, it is probable the excess of silver resulted from the galena.

Philadelphia, October 7th, 1869.

COMPOSITION OF THE NATIVE GOLD FROM VENEZUELA.

Communicated by CHAS. P. WILLIAMS.

SINCE the time of the ill-fated expedition of Sir Walter Raleigh to the Orinoco, down to the year 1865, nothing had been done towards the systematic exploration of the supposed existing auriferous region, situated in the State of Spanish Guayana to the south of that river, in the Republic of Venezuela. In that year Mr. L. M. Davis (then a student in my laboratory) was sent, under the auspices of J. B. Austin, Esq., formerly of this city, but who had for some years previously been a resident of Venezuela, to explore the mineral deposits of Guayana, and the result of his exploration has been the commencement of systematic and vigorous mining operations, which have resulted successfully, and which are now sending to the United States alone upwards of \$30,000 of gold monthly. The gold from this State is remarkable for its fineness. Mr. Davis has just completed, in my laboratory, the following analysis of a specimen (weighing 1.1114 grammes):

Gold.....	98.593 per cent.
Silver.....	8.637 "
Iron.....	1.60 "
Copper.....	.650 "
	99.480

A careful examination was made for platinum and associated metals, but no traces were discovered.

The specimen analyzed was from a placer in the bed of the Quebrada de Peru, department of Yuruari, Neuava Providencia or Caratal.

But little is being done towards working the placers (which are reported as being remarkably rich) the whole product of gold being obtained by operations on a system of quartz veins, containing but little pyrites. The upper portions of the veins consist of an auriferous gossan which is highly manganiferous, and from which gelatinous silica separates on treatment with acid. I hope soon to complete an analysis of this interesting gossan.

Philadelphia, Oct. 16th, 1869.

ON VARIOUS PROCESSES FOR PRESERVING TIMBER.

UNDER the above heading, there appeared in the last September edition of the *Journal of the Franklin Institute*, an article written by Dr. Adolph Ott, in which I have been, unfortunately, honored by the author, in mentioning my invention. He says:—

"The Process of S. Beer."

"Quite recently attention has been called to a process for preserving timber, invented by S. Beer, in New York. The same consists in the treatment of the wood in a boiling solution of borax in water, and came to our knowledge through a German periodical of last year. It is claimed therein, that all putrefiable substances are effectually removed by the borax; moreover, it is held that the ligneous fascicles become harder and less absorbent; that the treatment protects all the wood from insects; keeps it dry and inflammable. The process is carried on in the following manner." (Here follows a very defective description of my process.)

I thankfully accept the conceded inventorship of the borax process, but I am quite at a loss to comprehend why Dr. A. Ott was forced to hunt up a provincial periodical published for the Grand Duchy of Hesse, from last year, to get a knowledge of this American invention, a full and correct description of which is easily found in the New York papers, such as the *Scientific American*, *Artizan*, and others, or by application at the Patent Office in Washington, or at my own office, especially when it is known that he was personally introduced to me over a year ago, shortly after my American patent was issued, on which occasion he offered his kind services as a correspondent for American and foreign papers, to write upon this very invention. His offer I politely declined, because I did not want talk, but work, to further my invention. After an imperfect description of my process, he enters into the following criticism:—

"Let us now examine the process a little closer. The fact that borax is soluble in about 12 parts of its weight of cold water, makes this process inapplicable for structures which are to be exposed to terrestrial or meteoric waters, for the reason that the intended protective coating will be slowly removed."

No greater wrong could be done than representing me in the eyes of the readers of the *Journal* as using a protective coating by my process. I know too well the uselessness of any coating to preserve wood, because, if the fermentive matter is left in wood, it will decay within; and if the sap is removed from wood, then coating is quite unnecessary, as pure wood cannot rot, whatever may be its exposure to water or air, or both together.

My process, I have described to consist in removing the putres-

cible or nitrogenized sap-matter from wood altogether by means of borax, or some like compound, which effectually dissolves and extracts such matter without injuring the wood fibre. It is expressly stated in the specification of my patent, that the wood, after it had been treated with a solution of borax, "may be several times washed in boiling water, which will extract the absorbed borax in connection with the colored matter and restore the wood to its former color and appearance." Although borax is itself an antiseptic substance, I am very particular to wash out its last traces, because I know that there is no antiseptic equal in its antiseptic power to pure wood. The fact alone that there exist pieces of wood which are several thousand years old, without any other preparation than having been deprived of sap by washing in water during their transportation in the old slow way of rowing the timber on streams, proves that pure wood resists alteration more than any coating known. That my opinion herein is fully sustained by scientific researches, investigated first by De Saussure, and since then confirmed by all our celebrated chemists, will be seen by the following excerpts:—

"Wood, especially when under the influence of atmospheric vicissitudes, is rendered liable to decay from the decomposition of its albuminous* component; this circumstance favors the growth of lichen and fungi, and encourages the ravages of insects to which the albuminous portions in particular offer the means of nutriment."—William Allen Miller's *Elements of Chemistry*, Part III., page 95.

"The spontaneous decomposition of the vegetable albumen, acting as a ferment, is the primary cause of the decomposition of wood. Hence it is found that those woods which contain the smallest quantity of albumen and amylaceous matters are the most durable."

"If the decay of wood is, in the first place, an induced effect of the contact of decomposing albumen, a means of preserving the wood is naturally suggested in the removal of the albumen, or else in so modifying it, by causing it to combine with other substances, that it shall no longer possess the property of decomposing spontaneously. The solubility of albumen, in cold or tepid water, affords a

* All fermentive or putrescible substances are called, in science, "albuminous or nitrogenized" matters, because they contain nitrogen as an elementary component, which is the very element which renders such organic compounds liable to spontaneous decomposition. Wood substance contains no nitrogen, while the sap consists mainly of nitrogenized matters.

simple means of withdrawing from the wood this element of decomposition. Unless the wood is in very thin pieces, the removal of the albumen by the process of washing in water is extremely slow. To test the efficacy of merely washing in water, equal weights of washed and unwashed wood equally dry, were moistened with the same quantity of water, and the amount evaporated was replaced in each quantity equally. In the course of a few weeks the unwashed wood was always found to be covered with a thick mold, while none appeared on the washed wood. At the expiration of six months, the unwashed wood was found to have sensibly diminished in weight, while the weight of the washed wood remained unaltered."—Dr. Boucherie. This is literally copied from *Applied Chemistry*, by E. A. Parnell, Vol. I., p. 185. London: 1854.

Dr. Ott continues:—

"Again, borax being of a hygroscopic nature, if not refined with the utmost care, will soon absorb water, and thus leave the wood in a damp instead of a dry state. Naturalists, in selecting (!) borax crystals, well know that they have to coat them with a varnish, or otherwise they would soon become white or opaque, on account of their affinity to water."

It is true that borax crystals slightly effervesce on the surface, but Dr. A. Ott cannot really suppose that such effervescence is caused by affinity to and absorption of water. On the contrary, it is due to a drying up and loss of part of the water of crystallization. He must also know that hygroscopic salts are those which dissolve in their own weight of water, or less, and which melt (deliquesce) by absorbing the moisture of the air. Now, Dr. Ott himself states that borax wants twelve times its weight of water to dissolve: how can he represent borax as a hygroscopic salt? Indeed, Dr. Ott must very much underrate the intelligence of the readers of the *Journal* by his bold assertions, contradictory not only to knowledge, but also to common sense. He continues:—

"But a still more serious objection against the process consists in the property of alkaline fluids, such as a solution of borax, of dissolving, or at least attacking, certain substances of the wood upon which its strength, solidity, and toughness, and other desired properties greatly depend. These substances are the so-called incrustating materials (!). They form in concentric layers the inner walls of the ligneous cells, they being abundant in the hard wood and the stems of fruits, where they often fill the entire space of the cell. In the making of paper from wood, all that is wanted is the supple, pliant cell. The manufacturer's attention is therefore directed to the removal of the non fibrous bodies, which end he accomplishes by the boiling of the previously reduced wood in alkaline lyes; but the paper attained, though smooth and elastic, and capable of taking the highest finish, lacks that degree of firmness necessary to make it a fitting material for the better kinds of paper."

Borax, phosphate of soda, and some other like compounds, form a distinct class of salts, which, although being partly of a slightly alkaline reaction, differ very materially from caustic and carbonate alkalies, by being agencies for dissolving organic matters without in the least attacking or affecting the structural tissues or cellular membranes, however tender such may be, and however strong and in excess the solutions of these salts may be applied. By this their peculiar property, long known to chemists, I found them admirably adapted for seasoning, preserving and purifying wood; and my invention consists in applying the salts of this class for the purpose stated. I prefer to use borax, although I distinctly claimed the use of all like compounds, because borax is the most efficient, and thereby the cheapest salt, and because it gives to wood a much superior finish than any other; and lastly, because it is easily re-worked, and can be used over and over again.

An experiment, which is as interesting as it is illustrative, I will state here. The white of an egg well mixed with a solution of borax, and heated to boiling, will become clear thereby without coagulation, and all the tender cellular membranes (*tela cellulosa*) will settle on the bottom without being dissolved, however strong the solution may be, or however long the boiling is continued.

Paper-makers who use wood, would do well to dispense with potash or soda, and obtain a license to use borax, or a like compound, to purify wood from its non-fibrous matter; and I had them mainly in view in claiming the right of my process for purifying wood also. So much to dispel the fear which Dr. Ott may have caused in the minds of the readers of the *Journal* by his fancy that borax acts as a destructive agent, like potash or soda. He further says:—

“In the course of this article, I shall have occasion to dwell fully on the importance of the natural resin contained in timber, in its bearing on the durability of wood. It is certainly not an advantageous feature of the above-described process, that the resin is altogether removed by it.”

If it is true that the natural resin is very important for the durability of timber, how could wood decay with the natural resin therein? Resinous bodies, even gum copal, change by exposure to air and moisture. In the most favorable case they can only postpone the decay of wood. Weak solutions of borax, sufficiently strong to remove the soluble portions from wood, do not

much affect the natural resin in pine and spruce wood, as I know by experience; and, if desired, it is at will in the hands of the operator to leave it therein, though its presence is of no visible utility in our case.

He finally says:—

"In regard to its claimed superiority in withdrawing the putrescible substances, it may be stated, ON GOOD AUTHORITY, (experiments conducted at the College of the City of New York,) that 14 per cent. of albumen from the quantity originally contained in the wood, have been retained in SAW-DUST, after boiling the same several times, and each time FOUR HOURS, with a saturated solution of borax."

If true, this would be fatal to my invention, as only 86 per cent. of the albuminous matters would then be removed, while I claim to remove all.* The question is, what is his "good authority?" Prof. Doremus, and his assistant, Dr. O. Loew, are the only experimentalists in the laboratory of the College of the City of New York. Their ability, expertness, and veracity cannot be questioned. They both flatly deny their authority for such statement; and, to expose the love of truth of Dr. Adolph Ott, by his desire to enlighten the readers of the *Journal* on the subject, I publish the following letter:—

"NEW YORK, *September 29th*, 1869.

"SIGISMUND BEER, Esq.

"Dear Sir:—Pieces of wood, prepared according to your process by a solution of borax, have been carefully analyzed by me over a year ago, to ascertain the quantity of nitrogen retained. I found only weak traces of nitrogen therein, although I had used common Croton water for solution and washing. The same wood, unprepared, contained nearly $1\frac{1}{2}$ per cent. of nitrogen. The whole process of extracting the sap from the wood was performed in less than two hours.

"O. LOEW, *Assistant in the College of New York.*"

In conclusion, I may be allowed to indulge in a few general remarks concerning the subject in question. Decayed wood, when compared with wood in the sound state, shows an alteration in its substance. Such change is a purely chemical one, and brings the decay of wood within the category of a chemical process, which is always based on certain conditions, necessary to its accomplish-

* Weak traces of nitrogen are found in every organic substance when analyzed; they are only accidentally present, but they amount to nothing. Even distilled water contains traces of ammonium, and more will not be found in wood properly Beerized.

ment. By chemical investigation we know that the transformations occurring during decay of wood, are caused by the albuminous matter distributed over the cellular tissues, acting as a ferment, while in a state of spontaneous decomposition. Wood, therefore, which has been deprived of its albumen, has lost thereby its capacity to decay or rot. Surely it cannot be altered or decomposed by mere exposure to the combined action of water and air, so destructive to unprepared wood; and it is in this sense that I adopt the expression of our European critics, that by my preparation "wood is rendered practically indestructible."

Still, it is not preservation alone which wood advantageously acquires by my treatment. Other improved properties, which I may mention here, are *its increased strength* and *closer structure*, from the absence of foreign matter which, in ordinarily seasoned wood, distends its tissues, and furthers the quality of being more perfectly dried, without any loss from "shakes," and rendered unsusceptible to atmospheric changes consequent to the total removal of deliquescent matters. When I have added that the expenses are so trifling that the licensed Lumber Yard in Twenty-second street, near North River, New York City, is enabled to sell Beerized lumber at as low a price as ordinary dried stuff of the same quality, the progressive reader, acquainted with the squandering and destructive practice hitherto in use for curing lumber, will undoubtedly join in my confidence of a general adoption of the new plan at no distant time:

SIGISMUND BEER.

ON THE NEW CHEMICAL NOMENCLATURE.

BY DR. ADOLPH OTT.

(Continued from page 132.)

WITHOUT entering into the phraseology adopted by the adherents of the phlogistic theory, it is proposed to give an account of the changes effected in the nomenclature by the study of the properties of aeriform bodies, which precedes the great epoch in the history of chemistry inaugurated by ANTOINE LAURENT LAVOISIER, and denominated by the author of the History of the Inductive Sciences, the epoch of the theory of oxygen. The merit of having made the first attempt towards the introduction of a more rational nomenclature is due to MAEGNER and BAUME. To them we owe the change

by which the names of metallic salts are designated by the name of the acid and of the metal entering into their composition, that all the salts which are formed by the union of a metal and sulphuric acid, or oil of vitriol, are called *vitriols*; and *nitres*, if the latter acid is replaced by nitric acid. To TORBERN BERGMAN, then Professor at Upsala, in Sweden, chemistry owes a further attempt towards a more convenient set of names. They were first published in the UPSALA TRANSACTIONS, issued separately in 1782, and inserted in his work "Essays Physical and Chemical." Edinburgh, 1791.

"I am not ignorant" he says, in Vol. I., p. 11, "that words, like money, possess an ideal value, and that great danger of confusion may be apprehended from a change of names; in the meantime, it cannot be denied that chemistry, like the other sciences, was formerly filled with improper names." The names of salts of alkalies, earths and metals were composed by Bergman of a noun substantive to indicate the base, and an adjective to designate the acid, viz:

Alkali minerale phosphoratum for Phosphate of soda.

" " *nitratum* for nitrate of soda.

" " *aëratum* for Carbonate of Soda.

Alkali vegetabile vitriolatum for Sulphate of potassa.

" " *salitum* for Chloride of potassium.

" " *saccharatum** for Oxalate of potassa.

The earths were distinguished as *terra ponderosa*, *calx*, *magnesia*, *argilla*, and *terra silicea*.

The names of these salts were formed in the same manner as those of the salts of the alkalies, viz: *calx saccharata*, *magnesia*, *borazata*, *terra ponderosa*, *aërata*, &c. The metallic salts were named according to the same principle, viz: *stannum salitum*, *nickolum nitratum*, *cuprum acetatum*, *ferrum aëratum*. As to the others suggestions of Bergman, we must refer the reader to the above cited work. The article "Nomenclature" in Watts' Dictionary of Chemistry may also be consulted with advantage. While these and other changes were proposed, GUYTON DE MORVEAU, an accomplished lawyer at Dijon, France, and at the same time an enthusiastic student of the natural sciences, had formed another system of nomenclature, and it seems independent of Bergman. It was first published in the May number of the *Journal de Physique* of 1782, which, strange

* The discovery of the fact that sugar, in being treated with nitric acid, yields oxalic acid, is due to Bergman. It was the first instance of the artificial formation of an organic acid. Scheele proved, afterwards, that this acid was identical with the acid of the common sorrel.

as it may seem, was then the vehicle of the opinions and views of Stahl and Becker, the founders of the phlogistic school. DE MORVEAU, however, at that time, had not yet become a convert to the Lavoisierian theory.

The following is a specimen of Guyton de Morveau's system of chemical nomenclature:—

ACIDES.	SELS.	BASES.
<i>Vitriolique,</i>	<i>Vitriols,</i>	<i>Phlogistique,</i>
<i>Nitreux,</i>	<i>Nitres,</i>	<i>Calce,</i>
<i>Arsenical,</i>	<i>Arseniates,</i>	<i>Baryte,</i>
<i>Boracin,</i>	<i>Boraxs,</i>	<i>Cuivre.</i>
<i>Fluorique,</i>	<i>Fluors,</i>	<i>Argent,</i>
<i>Citronien,</i>	<i>Citrates,</i>	<i>Platine,</i>
<i>Oxalique,</i>	<i>Oxalates,</i>	<i>Mercure,</i>
<i>Sebacé</i>	<i>Sébates,</i>	<i>Esprit de vin.</i>

In the meantime, the oxygen theory made its way with unexpected rapidity among the best savans of the time. BERTHOLLET, already an eminent chemist, and known for his researches on the composition of ammonia and the fulminate of gold and silver,* solemnly renounced the phlogistic theory in 1785.

Indeed, it was soon so generally adopted in France, that Fourcroy promulgated its doctrines under the name of "*La chimie française*," a title which Lavoisier did not altogether relish. The extraordinary eloquence and success of Fourcroy as a lecturer at the Jardin des Plantes, had no small share in the diffusion of the oxygen theory; and the name of "the apostle of the new chemistry" which was first given him in ridicule, was justly held by him to be a glorious distinction.†

In England, the pneumatic doctrine was propagated by Cavendish, Kirwan, Nicholson, Tennant; in Germany by Bernebstädt, Girtanner, Klaproth and von Humboldt; in Holland by van Troostwyck and Lauwerenburg; in Italy by Spallanzani and Volta; in Spain by Proust and others.

* Fourcroy, in his "General System of Chemical Knowledge," asserts that Berthollet discovered also the real nature of the pretended "*dephlogisticated marine acid*," or chlorine gas. This needs correction. It was discovered by Scheele in 1774, and considered by him as a simple body. Berthollet, however, at the time of the publication of the above cited work (1804), still held it to be a compound of muriatic acid gas and oxygen, which explains the name "*oxymuriatic gas*," met with in the older chemical books. Since 1808, according to Davy, M. M. Gay Lussac, Thénard and Curandau laid claim to the ideas of "oxymuriatic gas" being a simple body, and of muriatic acid gas being composed of this substance and hydrogen; but these opinions, he adds justly, were stated by the illustrious discoverer in 1774.

† Cuvier, *Eloges*, I., p. 20. Whewell, *History of the Inductive Sciences*, II., 278. Third Ed.

by which the names of metallic salts are designated, the acid and of the metal entering into their composition; the salts which are formed by the union of an acid, or oil of vitriol, are called *vitriols*; and is replaced by nitric acid. To TORBERN at Upsala, in Sweden, chemistry owes a more convenient set of names. The UPSALA TRANSACTIONS, issued separately, his work "Essays Physical and Chemical,"

"I am not ignorant," he says, "that money, possess an ideal value, may be apprehended from the imagination by the early filled with improper ideas, became as easy and earths and metals were made and difficult."* tive to indicate the

Alkali minerale

"and that the names of compound-bodies the elements which they contain, and also, if

Alkali veg

relative proportions. Oxygen, being considered at

the only body capable of producing acids, the compounds

were subdivided into "primitive binary oxides," "variable

The "acidifiable binary oxides." Water, or oxide

argil" hydrogen was the only substance reckoned to the first class. In

the second division, most metallic oxides were included, and in the

the mineral acids. The latter were again distinguished by

specific names, terminating in *eux*, or *ique*, respectively, according

to the quantity of oxygen they contained; e. g., *acide sulfureux*,

acide sulfurique; *acide nitreux*, *acide nitrique*. When the appella-

tions of acids terminated in *eux*, the names of metallic and other

salts formed by them were made to end in *ite*; and in *ate* when the

acid ended in *ique*. Thus were formed, *sulfite d'ammoniaque*, or

sulfite ammoniacal, *nitrate de soude*, *phosphate de soude*, *carbonate de*

baryte, &c.

Thomas Thomson, in 1804, introduced the terms *protoxide*, *deutoxide*, *peroxide*, in order to distinguish the various stages of oxidation. This was one of the earliest improvements. The then known organic acids received arbitrary appellations, this system being not applicable for compounds consisting of elements united in various propor-

* Fourcroy's General System of Chemical Knowledge, I., p. 68.

originated the names: *acide suberique*, *acide succinique*, &c. However, of a later date are the prefixes *per* to the terminations *ie* and *ous*, *ate* and *ite*; the prefixes, such as *di*, *tri*, *sesqui*; the substitution of the names of the alkali metals and those of their oxides in the nomenclature of salts, and many others, to which atten-

(continued.)

EJECTOR CONDENSER.

Tests at Ryesholm Pit, near Dalry, Ayrshire.]

BY RANKINE, C. E., F. R. S., &c.—11 September, 1869.

I.—General Description of the Engine.

The engine on which the following experiments were made is a single cylindered double-acting horizontal steam engine. It drives a fly-wheel shaft, which, by means of a crank and connecting-rod, and a pair of bell-crank levers, works a pair of pumps for raising water from a pit. The work done by the engine at a given speed is thus practically constant. During the experiments a uniform speed of 22 revolutions per minute was kept up; and the indicated horse-power was $24\frac{1}{2}$. The cylinder is without a steam jacket, consequently some heat is wasted through condensation and re-evaporation in the cylinder, which might be saved if there were a jacket. Throughout the experiments the engine was worked at full steam, the admission going on from the beginning to the end of the stroke. The diagrams taken show a fall of pressure at the end of the stroke to the extent of about 3 lbs. on the square inch, below the initial pressure; and this is one of the effects of condensation in the cylinder. They also show a gradual formation of the vacuum, during the earlier part of the return stroke; and this is an effect of the re-evaporation of water previously liquified in the cylinder through the want of a steam jacket. The engine was originally non-condensing, and was converted into a condensing engine by the addition of an Ejector-Condenser.

II. Principal Dimensions of the Engine.

Stroke.....	4½ feet.
Diameter of cylinder.....	18 inches.
Area of piston (allowing for half piston rod).....	252 square inches. = 1.75 square feet.
Space swept by piston per revolution.....	15.75 cubic feet.
Space swept per minute at 22 revolutions.....	346.5 cubic feet.
Mean speed of piston, at 22 revolutions per minute.....	198 feet per min.

III.—General Description of the Experiments.

The engine being kept working at the before-mentioned steady speed of 22 revolutions per minute, the quantity of water discharged from the condensing apparatus was measured by means of a suitable gauge; and the rise of temperature of that water was ascertained by comparing together two thermometers, one in the cold well and the other in the hot well. Thus were obtained data for calculating the total expenditure of steam, from its heating effect on the condensation water. Indicator diagrams were also taken to show the power, and the pressure and vacuum in the cylinder when working as a condensing engine. The exhaust pipe of the cylinder was then disconnected from the condensing apparatus, and made to discharge the exhaust steam into the air. The engine was thus made to work as a non-condensing engine, at the same speed and against the same load as formerly; and indicator diagrams were taken to show the pressure in the cylinder under these circumstances. All the diagrams showed the same mean effective pressure, viz: 16.2 lb. on the square inch; and the same power, viz: $24\frac{1}{2}$ I. H. P. The boiler pressure, as shown by the steam gauge, ranged from 29 to 32 lbs. on the square inch above the atmosphere; but in all the experiments, whether with or without condensation, the pressure in the cylinder was greatly reduced by means of the throttle valve. The vacuum gauge, when condensation was used, remained almost perfectly steady at 24 inches = 11.76 lb. on the square inch; and this is sensibly identical with the greatest vacuum shown by each of the diagrams.

IV.—Experiments made without Condensation.

Initial pressure of steam lbs. on the square inch above atmosphere.....	19.
Final pressure, ditto.....	16.
Weight of steam expended in lbs. per hour, as calculated from final pressure in cylinder.....	1578.
Ditto in lbs. per I. H. P. per hour.....	61.4
Weight of steam expended in lbs. per hour, as calculated from initial pressure in cylinder.....	1731.
Ditto per I. H. P. per hour.....	70.7

V.—Experiments made with Condensation.

Initial pressure of steam lbs. on the square inch above atmosphere.....	9.
Final pressure, ditto.....	6.
Vacuum at end of exhaust, lbs on the square inch.....	11.7
Weight of steam expended in lbs. per hour, as calculated from final pressure in cylinder.....	1086.
Ditto per I. H. P. per hour.....	44.3
Weight of steam expended in lbs. per hour, as calculated from initial pressure in cylinder.....	1234.
Ditto per I. H. P. per hour.....	50.3

Hence it appears that when the expenditure of steam is computed from the indicator diagrams, it is found to be reduced by the addition of the condensing apparatus to about *seven-tenths* of its previous amount, when the engine is doing the same work,—in other words, the saving is 30 per cent.

VI.—*Result of Experiments on the Condensation Water.*

The quantity of water discharged from the condensing apparatus was gauged by causing it to pass out of a tank through an accurately turned and measured circular orifice in a thin plate of sheet iron, and measuring the height above the centre of that orifice at which the surface of the water in the tank stood. The following are the data and results:—

Diameter of the orifice, inches.....	3.5
Total area in fractions of a square foot	0.06682
Effective area, the coefficient of contraction being 0.618	0.0412
Head of water in tank.....	1½ feet.
Velocity at contracted vein produced by that head, feet per second....	9.03
Discharge, cubic feet per second.....	0.872
Do. do. per minute.....	22.32
Do. do. per hour	1339.2
Do. lbs. per hour.....	8343.0
Temperature, cold well	52° Fahr.
Do. hot well.....	70° "
Difference.....	18° "
Units of heat (British) per hour given by the steam to the water, very nearly.....	1,520,000
Total heat of steam from 52° at 23.° (being the temperature corresponding to final pressure in cylinder). British units.....	1,131
Total steam condensed in lbs. per hour, as calculated from effects on water of condensation.....	1828
Ditto per I. H. P. per hour.....	51.2

The excess of the total expenditure of steam as thus computed, above the expenditure as shown by the diagrams, is to be accounted for mainly by condensation and re-evaporation in the cylinder which go on in all engines not provided with steam jackets.

VII.—*Further Comparisons of Expenditure of Steam.*

The calculations of the expenditure of steam in lbs. per hour, and in lbs. per indicated horse-power per hour, with and without condensation, are here recapitulated:—

	<i>With Condensation.</i>	
	Lbs. Steam per Hour.	Lbs. Steam per I. H. P. per Hour.
A. Calculated from final pressure, as shown by diagram	1086	44.8
B. Calculated from initial pressure, as shown by diagram, the fall of pressure during admission being ascribed to liquefaction in the cylinder.....	1234	50.3
C. Calculated from effects on temperature of water discharged.....	1828	54.2
<i>Without Condensation.</i>		
D. Calculated from final pressure, as shown by diagram	1678	64.4
E. Calculated from initial pressure, as shown by diagram, the fall of pressure during admission being ascribed to liquefaction in the cylinder.....	1781	70.7

The difference between the numbers marked *B* and *C* in the preceding table, viz: 94 lbs. per hour, or 3.9 lbs. per indicated horse-power per hour, being 7 per cent. of the total expenditure of steam

marked *C*—represents the quantity of steam lost, or ineffectively expended, through the following causes:—

1. Filling cylinder-ports and clearance.
2. Liquefaction immediately on entering the cylinder (followed by re-evaporation during return-stroke).
3. Leakage past the packing of the piston.
4. Expenditure at the starting-jet of the condensing apparatus.

It is evident, however, that the first three causes alone are sufficient to account for the whole, or nearly the whole, of a waste of steam amounting to 7 per cent of the whole expenditure; and this is in accordance with the fact that, during the working of the engine, the cock of the starting-jet is kept so nearly closed that the escape through it must be almost inappreciable, being just sufficient to prevent the suction of air at the small hole in the cylinder of the self-acting piston-valve, by which the starting-jet is regulated.

When the engine was worked without condensation there were no means of measuring the total expenditure of steam, including waste, as there were when condensation was used. If we assume, however, an allowance which is commonly made in practice for clearance, leakage of piston, packing, &c., viz: 5 per cent., we obtain the following *probable* estimate of the total expenditure of steam *without condensation*:—

	Lbs. Steam per Hour.	Lbs. Steam. per I.H.P. per Hour.
<i>E.</i> Expenditure, as already calculated from initial pressure	1781	70·7
Add 5 per cent. for clearance, leakage, &c.....	87	3·5
<i>F.</i> Probable total expenditure without condensation.....	1818	74·2
<i>G.</i> Total expenditure with condensation, as before.....	1828	54·2
Difference, being net saving by the use of the Ejector-Condenser.....	490	20·0

Being 27 per cent. of the greater expenditure. This, however, is probably a low estimate of the savings, for it is based on a low estimate of the waste of steam in the non-condensing engine.

VIII.—*Useful Work.*

The useful work done by the engine is calculated from the following data:—

Diameter of bucket of each of the two pumps	10½ inches.
Stroke.....	4 feet.
Height of lift.....	25 fathoms = 150 "
Double strokes per minute, 5-8ths of number of revolutions of engine or	12½

The results are:—

Work, foot-lbs. per minute	550,368
Effective horse-power	16·68
Indicated horse-power, as already stated.	24·5
Inefficiency, or ratio of effective to indicated power.....	0·68

That is to say, 34 per cent. of the indicated power is the power expended in overcoming the friction of the pistons, valves, mechanism

of engines and pumps, and pump plungers, and the resistance of pipes and valves to the motion of the water raised by the pumps.

IX.—*Conclusions.*

The principal conclusions to be drawn from the experiments are, that the use of the Ejector-Condenser effects a saving of steam, as compared with the expenditure of steam by the same engine when doing the same work without condensation, which certainly amounts to 27 per cent., and probably to 30 per cent.: that there is probably a greater proportionate saving in the fuel burned; for it is well known that a diminution in the absolute quantity of fuel burned in a boiler increases the proportionate evaporative power of the fuel, by diminishing the waste of heat: that there is a steady vacuum of 24 inches of mercury, or 11.75 lbs. on the square inch: that the expenditure of steam by the starting-jet is certainly very small, and probably almost inappreciable: that the condensing apparatus is easily manageable and not liable to get out of order: and that it has been added to the engine without requiring any addition to the size of the engine-house, and without causing any inconvenience by the space which it occupies there.

It may be remarked that the present example of the Ejector-Condenser, having been originally intended for a larger engine, discharges a quantity of water greater than is absolutely necessary for the condensation of the steam, and therefore at a lower temperature than if the condenser had been specially designed for the engine; and that it therefore does not show the advantages of the Ejector-Condenser to their full extent.

THE U. S. CABINET OF PRACTICAL GEOLOGY AND MINING.

UNDER the direction of the Commissioner of the General Land Office, the HON. JOS. S. WILSON, a cabinet has been organized at the seat of the government, for the collection and preservation of a complete system of geological and mineralogical memorials of the whole country, especially of the public domain, and an alcove surmounted by the coat of arms of each State has been assigned for the preservation of the particular specimens of each State and Territory. The special organization of the cabinet was put in charge of Mr. A. R. ROESSLER, formerly connected with the geological survey of Texas, and member of the Imperial Geological Institution of Vienna. The specimens have been arranged on scientific and systematic bases looking to the presentation of a synopsis of the principal geological subdivisions with the different periods and epochs upon a

regular scale. The cabinet illustrates the character of the minerals from every part of the country, and the government will be enabled to collect more reliable statistics and more accurate general information than can be obtained by any other method; it includes the mineral products of the whole country, so arranged as to give at a glance an idea of the resources of each State and Territory, viz: 1st. A series of all the ores, native metals, useful minerals, coal, salt, sulphur, mineral waters, limestone, marls, native fertilizers, fire clays, building materials, &c. 2d. A collection of all specimens that throw light on the geological structure of the country, such as fossils and lithological or rock specimens. 3d. It is in contemplation to collect models of all mining and metallurgical machinery, implements, apparatus and specimens of all the various products of metallurgical processes, such as regulus and mat, slags and other furnace products, dressed and concentrated ores, amalgams and tailings. 4th. Sections, models and working plans of mines, to illustrate the principles and practical application of mining engineering.

The brief career of this cabinet so far proves that it supplies a *want*, that it represents a great interest in the country, and it is already looked to by an industrial class, the mining population, equal in intelligence and importance to any other, for encouragement and assistance. To bestow this advantageously, the cabinet should be enlarged and supplied with the means and skill, to examine and report on the mineral products received. More especially are needed, large suites of domestic and foreign minerals for comparison, care being taken that any so obtained shall be authentically labelled and arranged according to the most approved scientific methods.

It is evident that to accommodate the enormous collections that will ultimately be made, a suitable building should be provided at the outset. This edifice should be erected especially for the purpose, inasmuch as there is nothing of the kind in Washington that could be made available. The suite of rooms in the General Land Office now devoted to the cabinet would hardly hold a fraction of the collections necessary to illustrate, even in an imperfect manner, the universal wealth of a territory so vast as the United States. The collections already made since the organization of this cabinet would fill such a place many times to overflowing. Besides this, the collections of the various government surveys and expeditions, now stored in the cellars of the Smithsonian Institution and in part elsewhere would belong legitimately to this cabinet.

To dwell on the necessity that exists for such an institution is perhaps hardly requisite. All the leading governments of Europe, where mining forms at all an important source of revenue to the country, possess their museums, and we are, of all the great powers, the only one without a mining bureau or cabinet. The United States are usually not in the rear of nations in the march of improvement or in the fostering of enterprise, calculated to advance the prosperity of the country. The dignity of the nation demands such a museum; it is needed because without it, it will be impossible to obtain a clear idea of or accurate information regarding the mineral resources of all the States and Territories.

The reports of the Commissioner of Mining Statistics are good, so far as they go, but the system is a defective one; it does not cover half the ground, and the information is derived, at best, from imperfect data. Such a report loses half its value, from not being illustrated by specimens of the minerals and ores described. It is also too local in its character, describing the resources of but a limited region. But the cabinet will illustrate the character of the minerals from every part of the country; it is the first step in the right direction, and will be the natural outgrowth of the future National Bureau of Mines of the United States of America.

No department in the government is so well adapted to the organization of such a museum as the General Land Office, the beneficial influence of which never has been so deeply felt, since it has been under the direction of such a distinguished talent, as that of the HON. JOS. S. WILSON. The nature of the occupation of its employees brings them more in contact with the miner and quarryman than any other of the officers of the government. They meet the miner in the field and possess an advantage in this respect over the Tax Collectors. The surveyor is usually also from his training, better qualified to collect suitable specimens understandingly. The ramifications of the Land Office extend into all, or nearly all the mining regions and its officers can, with but little additional labor, procure proper material for the formation of such a museum as the one contemplated.

The question will naturally arise in the minds of those acquainted with the subject—what benefits are to be gained? what good will come from the foundation of this museum? The benefits are numerous and varied. Through it, we will be able to obtain more accurate information than is possible at present, of the character

and relative value of the mineral products of all sections of the country, and more reliable statistics of our mineral wealth as a nation than by the present plan of the employment of a Commissioner of Mining Statistics. The government would be in constant communication with all persons in the country, who are in position to give accurate information on these subjects, and would not have to depend on the interested statements of mine owners and superintendents or of irresponsible parties, anxious to magnify the importance of their own districts at the expense of truth and the disparagement of their neighbors. It will enable the respective employees to utilize the results of government surveys and explorations, and to furnish to the government useful data on which to base mining legislation, in order to obtain in the most satisfactory and efficient manner, the revenue from this department of the national wealth.

Another result, and by no means the least that we foresee, is: the accumulation of reliable information on the subject of working metals, whereby the processes in each case can be ascertained. This will prevent the waste of many times the amount of money which the whole enterprise will cost.

Every year millions of dollars are thrown away in fruitless attempts to accomplish satisfactory results in the working of ores. This can never, of course, be entirely checked, though the more intelligent class of miners is anxious to learn, and many would avail themselves of these means of enlightenment who now work in the dark, simply because they have no means of knowing better.

We might go on detailing arguments in favor of the enlargement of the cabinet, almost *ad infinitum*, but we shall desist. The present cabinet has been built up without any appropriation from the government, and, comparatively small as it is, is an earnest of what can be done if the proper authorities lend a helping hand. We cannot but believe that Congress will take the matter in hand in a liberal spirit, if the members can only be made to understand the importance of the undertaking. We have in the new countries between the Pacific States on the west, and the eastern base of the Rocky Mountains on the east, a region large enough for an empire in itself, and abounding in minerals. Untold wealth awaits the labors of the hardy miner and demands that the government, whom the people has placed in the exalted position of trustee of all the interest, mining included, should provide what is necessary for the full development of the immense mineral resources of our country.

ON ELECTRICITY APPLIED TO REGISTERING VIBRATIONS.

BY PROF. LE ROY C. COOLEY.

IN a recent number of this *Journal*, (January, 1869,) I described an *Electric Register*, with which, by the application of electricity, a direct registry of vibrations may be made in all cases where the motion has an appreciable amplitude. The possibility of studying the relation of the tones of stringed instruments was at the same time hinted, but the experiments in this direction were made without the precautions necessary to secure accuracy. They were then mentioned only to suggest this interesting application of the instrument, and the results, as they were unfortunately made to appear, were not such as to inspire confidence in the method. More careful experiments have since been made, and the actual pitch of *all the tones*, in a little less than *three octaves* of the piano, has been determined.

For a description of the registering instrument, and the method of making the necessary and delicate adjustments, the reader is referred to the former paper. A few words only may be here added to that explanation of its action.

The vibrations of the wire are made to occur in a vertical plane opening and closing an electric circuit with corresponding rapidity, and a dot is made upon the moving paper at the moment when the lowest point in the vibration is reached. The experiment begins when the wire is above its line of rest: the first dot, therefore, represents one-half of one complete vibration. Should the experiment end when the wire is at the highest point in its motion, the number of dots would show the exact number of complete vibrations made; but since it may end when the wire is at any point of its path, there may be a possible error of less than one-half of a complete vibration in an experiment one second in length. As the time is lengthened, the error is diminished; in a registry of five seconds the maximum error would be less than one-tenth of one vibration per second.

The precision with which the laws of vibration may be verified by the use of this instrument is in the highest degree satisfactory. However numerous the repetitions of an experiment may be, the registry varies only by a single dot. Moreover, it makes the law rest upon no comparison of sounds produced by the vibrations, nor upon any other effect of the motion, but upon the vibrations them-

selves, whose numerical relations are directly shown. Vibrations, sonorous or otherwise, are thus equally the subject of experimental investigation.

But to return to the experiments made upon the vibration of the piano wires, with a view to register the *standard pitch*, and, at the same time, to furnish the data upon which to study the numerical relations of the intervals in the scale.

Mr. Harwood, with Chickering Sons, Boston, very kindly transmitted the pitch of the *Boston Music Hall Organ* to Prof. T. Spencer Lloyd, of Albany, at whose request, also, Mr. G. N. Collier, with much care, put a piano in tune with that famous instrument. It may, therefore, be assumed that the piano whose vibrations have been registered represents the present standard pitch.

The piano, with its needle attachments, being in tune, and the register being carefully adjusted, a series of experiments, covering nearly three octaves was made, and the results, each being the mean of three experiments, are given in the following table.

This table of vibration differs from all others relating to music, so far as I know: first, in being the result of a *direct registry*; and second, in that it shows *all the intervals of the scale*.

1st Octave (lowest).		2d Octave.		3d Octave.	
NOTES.	No. of Vibs. per second.	NOTES.	No. of Vibs. per second.	NOTES.	No. of Vibs. per second.
C	30.8	C	61.5	C	123.1
C $\sharp$	32.7	C $\sharp$	65.5	C $\sharp$	130.8
D	34.7	D	69.3	D	138.5
D $\sharp$	36.7	D $\sharp$	73.4	D $\sharp$	146.7
E	38.7	E	77.4	E	154.7
F	41.8	F	83.5	F	166.6
F $\sharp$	44.2	F $\sharp$	88.3	F $\sharp$	176.5
G	46.8	G	93.5	G	187.1
G $\sharp$	49.4	G $\sharp$	98.7	G $\sharp$	197.4
A	52.2	A	104.4	A	208.5
A $\sharp$	54.4	A $\sharp$	108.7		
B	57.7	B	115.7		
C	61.5	C	123.1		

The octave above the last note (A = 208.5) in the above table, is the *la* usually referred to in describing the pitch of the orchestra.

It would, according to this registry, be produced by 417 *complete vibrations per second*.

In the time of Louis XIV., the pitch of this A was, according to Sauveur, 405 vibrations per second, while by the action of the Congress called together by the Society of Arts, at London, in 1860, it was 440. The same note sounded by Handel's tuning-fork (1740) is said to have been made by 416 vibrations per second. It will thus be seen, that while the present pitch is nearly one-half of a tone higher than that referred to by Sauveur, and considerably more than that interval lower than that of the London Congress, it agrees with the pitch adopted by Handel to within a single vibration.

EASY RULES FOR ASTRONOMICAL REFRACTION.

BY BENJAMIN SMITH LYMAN.

IN using the solar compass, as well as other astronomical instruments, the refraction of the atmosphere must be taken into account as changing the apparent place of the sun or other heavenly body. In the zenith, the apparent place of such a body is not affected by refraction, but everywhere else it is raised above the true place; little near the zenith, but more and more towards the horizon, and some thirty-five minutes at the horizon. The amount of displacement changes too with changes in the weight and heat of the air, as shown by the barometer and thermometer. Near the horizon the refraction is great and changes very fast with a small change of the true height or altitude; and as the rays of light then pass for a greater distance through the air, and through much of it quite near to the earth's surface, they are greatly exposed to change from variations along their path in the weight and heat of the air, variations that clearly must be quite unknown. Hence, astronomers say that no table of refraction can be depended on within five degrees of the horizon, although tables are given all the way from the zenith down to the horizon.

It is customary to calculate the refraction for any given height of a heavenly body, and for any state of the air, by means of these tables and by complicated formulas. But for the solar compass, which has no means of marking the refraction nearer than to full minutes, and, indeed, for sextants or other instruments that do not read closer than to five seconds, two or three very simple rules are as good as the tables for all heights above three degrees and

a-half; and observations should not be made lower than that, at any rate. These rules are very easy to remember, and by them the refraction can readily be calculated in the head.

The first rule is for the mean refraction—that is, the refraction when the barometer is at thirty inches and the thermometer at fifty degrees, Fahrenheit. *Add one degree and three-quarters ($1^{\circ} 45'$) to the true altitude, and divide sixty-eight degrees (68°) by the sum; take one-half ($\frac{1}{2}$) from the quotient, and the remainder will be the number of minutes of mean refraction.* For example, to find the refraction for a true altitude of seven degrees and fifty-eight minutes:

$$\begin{array}{r} 68^{\circ} \\ 7^{\circ} 58' + 1^{\circ} 45' \overline{) 68^{\circ}} - \frac{1}{2} = 9^{\circ} 43' - \frac{1}{2} = 7 - \frac{1}{2} = 6\frac{1}{2}; \end{array}$$

and the refraction is six minutes and a-half, exactly as given in the table of refraction in *Chauvenet's Astronomy* (1863). With an instrument, like the solar compass, that marks the refraction only to the nearest full minute, the whole number of the quotient will simply be taken as the refraction: as seven in the example just given. For plainly any quotient between seven and eight would answer to a refraction between six and a-half and seven and a-half—that is, in round numbers to seven.

The following table, chiefly for every odd half minute of refraction, shows the altitudes down to two degrees, for which these amounts of refraction are calculated by the rule, and the refraction for the same altitudes by the tables, and the difference between the two, or the error of the rule.

It is clear, that for any altitude above two degrees and a-half, the rule is quite exact enough for any instrument that does not read closer than half minutes, and from three degrees and a-half up to sixty degrees for any instrument that reads only to five seconds.

The second rule is for instruments that read to five seconds. *The mean refraction between the zenith and fifty-seven degrees (57°) altitude is eleven tenths of a second ($1''.1$) for every degree of distance from the zenith.* For example, the refraction at 75° of altitude is, by this rule $16''.5$, or only one second more than is given in the tables, and this is the greatest error of the rule anywhere above 59° , and at 57° the error is only $1''.5$.

The third rule is for the allowance to be made for changes of the barometer and thermometer, and is simply: *Add to the mean refraction at the rate of doubling for a rise of thirty inches in the barometer, or for a fall of five hundred degrees in the thermometer.* The refraction

tion should, of course, be lessened at the same rate for a fall of the barometer or rise of the thermometer. For example, when the barometer is at 31.5 inches, and the thermometer at 75° , the mean refraction of ten minutes becomes $10 + \frac{1}{3}\% \times 1.5 - \frac{1}{3}\% \times 25 = 10 + 0.5 - 0.5 = 10$; that is, it is unchanged. The rule is exact for the

TABLE I.

True Altitude.	Refraction.		Error of Rule.
	By Rule.	By Table.	
90° 0	0' 14'' .4	0' 0'' .0	+ 14'' .4
68 0	0 28 .5	0 23 .6	+ 4 .9
66 15	0 30 .0	0 25 .6	+ 4 .4
60 0	0 36 .0	0 33 .6	+ 2 .4
57 0	0 39 .6	0 37 .8	+ 1 .8
32 15	1 30 .0	1 32 .0	— 2 .0
20 55	2 30 .0	2 31 .0	— 1 .0
15 15	3 30 .0	3 29 .7	+ 0 .3
11 51	4 30 .0	4 29 .2	+ 0 .8
9 35	5 30 .0	5 29 .3	+ 0 .7
7 58	6 30 .0	6 30 .0	0 .0
6 45	7 30 .0	7 31 .0	— 1 .0
5 48	8 30 .0	8 29 .9	+ 0 .1
5 3	9 30 .0	9 32 .3	— 2 .3
4 26	10 30 .0	10 31 .0	— 1 .0
3 55	11 30 .0	11 29 .5	+ 0 .5
3 29	12 30 .0	12 28 .5	+ 1 .5
3 6	13 30 .0	13 27 .2	+ 2 .8
2 47	14 30 .0	14 40	— 10
2 30	15 30 .0	15 19	— 11
2 15	16 30 .0	16 9	— 21
2 2	17 30 .0	16 58	— 32

barometer, and agrees with Chauvenet's tables, between fifty and a hundred degrees of the thermometer, but gives slightly too little refraction for a low state of the thermometer. This error, however, at ten degrees below zero is, according to Chauvenet's tables, only eighteen seconds for a mean refraction of ten minutes; and according to the tables given in *Norton's Astronomy*, is only eleven seconds. At zero, the error for the same mean refraction would be only fourteen seconds, by Chauvenet's tables. This rule, then, is

quite exact enough for any instrument that does not read closer than half minutes, and with all ordinary weather and altitudes, even for instruments that read to five seconds.

The following table gives the true and apparent altitudes down to five degrees for every odd half minute of mean refraction—that is, the altitudes at which the amount of refraction changes from one minute to the next, when only full minutes are taken account of, as in the solar compass.

TABLE II.

Altitude.		Refraction.	
True.	Apparent.	Exact.	Nearest Minute.
90° 0'	90° 0'	0' 0''	
62 46	62 46	0 30	0
32 40	32 42	1 30	1
21 8	21 5	2 30	2
15 14	15 17	3 30	3
11 49	11 53	4 30	4
9 34	9 39	5 30	5
7 58	8 4	6 30	6
6 46	6 54	7 30	7
5 50	5 58	8 30	8
5 5	5 14	9 30	9
4 27	4 38	10 30	10

The foregoing tables have been made from the tables in *Chauvenet's Astronomy*, with the help, also, of the older ones given in *Norton's Astronomy* (edition of 1867).

135 South Fifth Street, Philadelphia.

10th September, 1869.

ON VARIOUS PROCESSES FOR PRESERVING TIMBER.

BY DR. ADOLPH OTT.

(Concluded from page 248.)

On the properties of resinous timber, and the unchangeability of resinous substances in general.

AMONG the various woods which are used either in house, ship-building, or other purposes, we meet some which, though even when not operated upon by chemical agencies, are renowned for their

extreme durability. It is especially wood of close texture that is rarely attacked. Moreover, it is known that wood rich in resin is extremely durable, withstanding the action of heat and moisture, when other kinds will soon decay. This fact seems already to have been known to the ancients, for Pliny says the more odoriferous timber is, the more durable it is.

The longer a tree has been used for pitch, the less durable is the timber that it yields; and it may be asserted that the wood of the coniferæ which is so useful for all kinds of carpenters' work, owes its qualities greatly to the large quantities of resin secreted in its tissues, they rendering it impermeable to water, and thus capable of withstanding its action. The resin becomes concrete after death by the evaporation of the essential oils which held it in solution. SCHACHT, in his splendid work, "*Der Baum*" (the tree), pp. 188 and 190, relates several instances of the wonderful durability of resinous timber. This author examined the ruins of the castle Ehrenstein, near Remda, Thuringia, one of the oldest extant in Germany, and found the wood (yellow pine), perfectly sound, and but a little turned brown. The old wood of the Canarian pine is also nearly imperishable on account of the resin diffused in its tissues. Schacht relates that the wood work of the column of the Patio and its galleries in the dwellings on Teneriffa and Gran Canaria, is as well preserved as if freshly felled. They were erected at the time of the Conquista, in 1402.

WILLIAM W. BATES, in the article already referred to, relates numerous instances of the great durability of resinous timber, among which the following may find a place here: the red and white pines of Oregon are largely used on the Pacific coast in the construction of the various parts of vessels. They are considered so well fitted for this purpose, that vessels have been constructed entirely from the denser sorts of pine timber, both in Oregon and California. The yellow, or long leaved pine of Virginia and North Carolina is extensively used by Atlantic ship-builders for planking, ceiling, stringers, beams, water ways, rails, keelsons, &c. It is very durable, and when a lighter, yet solid wood is required, it is preferred to oak of whatever kind. The white, or northern pine, according to Bates, is found at the head of the list of the softer woods used in building vessels of every description. For the construction of river steamboats it is invaluable, and is sometimes used in almost every part of the boat, except the frame, above light water mark.

No wood is said to be better adapted to withstand the sun and weather ; for, with proper seasoning and reasonable protection, after the work is finished, it retains its properties as long as the best kind of oak. The wood of the hackmatack or tamarack (the American larch), which is known for its density as well as for its gummy nature, is used for vessels in every part. The sap-wood should of course be excluded in this, as well as in all other instances, but the heart wood requires no seasoning before use, the shrinkage in weight being less than two pounds per cubic foot. For lightness, strength, tenacity and durability it is unequalled. The red or Norway pine, when deprived of its sap-wood, is found to be a first-class material for top timbers, beams, deck planks, bulwarks, and ceiling ; it affords excellent timber for masts, when large enough, and for all kind of small spars. The roots make very good knees and breast-hooks.

Another proof of the unchangeability of resinous matters is the amber, which formerly was considered as being of mineral origin, but is now decided upon to have secreted in a fluid state from the coniferæ of the upper tertiary and secondary strata. According to a myth of the ancients, the Heliades, in weeping over the death of their brother Phaëton, were transformed by the gods into poplars, and their tears into amber. Indeed, it is a tear of times past, the remainder of a long gone luxuriant life, for this is shown by its constant occurrence with lignite and bituminous wood. From the fragments of vegetable organisms enclosed in it, it has been inferred that the flora of the northern hemisphere at that time must have been very similar to that of the northern part of the United States. GOEPPERT calls it the "amber flora." Amber enclosing wasps, ants and flies is quite abundant. Their frailest parts, as antennæ and legs are still well preserved, and spread naturally, while the insects which are so often noticed in the resinous exudations of our northern coniferous trees show always a bent body, crooked legs, and curled wings. This seems to show that the amber, unlike the rosin, must have passed very slowly from the fluid into the solid state. With respect to its chemical nature, it closely resembles the ordinary resins, but differs from them in yielding a peculiar acid, the succinic acid, in being treated with alkaline solutions. GOEPPERT succeeded in producing it artificially from Venetian turpentine, in digesting the same with twigs of the larch for twelve months in water of from 140 to 175 degrees Fah.

Additional proofs of the preservative action of resins may be gathered in a perusal of Joseph Pettigrew's work on the Egyptian mummies, in which it is conclusively proved that the bodies of the inhabitants of the Nile valley must have been impregnated with resinous and bituminous substances.

THE HEINEMANN PROCESS.

The foregoing remarks on the properties of resinous timber and the preservative action of resinous substances, have been considered necessary for the better understanding of a process which it is proposed now to examine. The same was invented by Mr. T. W. HEINEMANN, of New York, it being the one proposed to be adopted by the Street Commissioner of that city in the construction of the piers, docks, and bulkheads to be built by her corporation.

The inventor first expels the sap from the wood, so that the pores are left free and open for the injection of the preservative agent, which is common rosin, or colophony. The latter is introduced while in a liquid state, and under high pressure in vessels especially constructed for the purpose. From the appended letters of Professor R. OGDEN DOREMUS, of the City College, New York, it appears that one cubic foot of "green" wood absorbs on the average 8.96 pounds of rosin (the minimum being 3.39, the maximum 15.8), while one cubic foot of old, seasoned timber, absorbed but 2.66 pounds, or only one-third of the amount of the fresh one. I am not inclined to ascribe to these analyses a great value, for I am informed that the wood treated was neither of the same age, nor on the same site; but they show at least that the timber may be thoroughly impregnated by the process in question. According to the data given, green wood had absorbed sixteen per cent. in weight, while seasoned wood had taken up five per cent., both numbers indicating the average. These data might give rise to serious doubts as to the economy of the process, but we are informed that it is not intended to charge the wood in such a degree. However, common timber, such as hemlock, spruce and cotton wood, upon being treated with this process can be substituted for the hard and expensive oak and chestnut. Again, assuming, as we may properly do, that the injection with rosin will really preserve timber, the process must effect a vast saving by obviating the necessity of frequent reconstruction which at present is especially necessary for trestle work, railroad ties, and telegraph poles. Another important advantage

of the process consists in that, that the strength or resistance of strains, crosswise and compressive, is considerably increased. This fact has been ascertained by a series of experiments, some of which follow hereafter, and of itself enhances the value of the process.

TREATED WOOD.			UNTREATED WOOD.		
Breaking Pressure	Quality	Size 1 in. x $\frac{5}{8}$ in. Grain	Breaking Pressure	Quality	Grain
163½ lbs.	Somewhat checked	Straight	98½ lbs.	Sound	Slant
198 " "	Sound	"	108 "	"	"
171½ "	"	"	116 "	"	Straight
			Size ½ in. x $\frac{5}{8}$ in.		
72½ "	Checked	Straight	57½	"	"
57½ "	"	Cross	46	"	"
57½ "	"	"	46	"	"
			Size ½ in. x $\frac{3}{4}$ in.		
121 "	Checked	Cross	71	"	large & straight
161½ "	"	Slant	84	"	"
121 "	Sound	"	71	"	"

We have no doubt that spruce, when treated by the Heinemann process, can advantageously be substituted for the more expensive kinds of yellow and white pine, and that the difference in cost will more than pay the outlay for the treatment. It seems to us to be especially fitted for ties, piers, bridges and wooden pavements. The blocks for these latter would remain water-tight, the crushing strength would be increased, and as to the preservative itself, we think that none more salubrious could be employed; to say the least, it is to be preferred to any ingredient having a strong, smoky, and disagreeable smell, as employed in certain alleged wood preserving processes.

One objection has been raised against the described method, viz.: that wood impregnated with rosin would be more inflammable than air-dried timber not treated. On this point, the inventor expresses himself as follows:—

"The impregnated tie is not more liable to injury by fire than one unimpregnated and properly seasoned. The first impression naturally is the reverse of this. Singular as this may appear, it is no less true. The inventor himself was not aware of this, until by accident he discovered it, and by repeated experiments demonstrated it. The *rationale* seems to be, that the rosin, which burns first alone, deposits, while burning, an air-tight coating of some unflammable slag upon the surface of the tie, thereby preventing the fire from penetrating deeper. Combined with this, however, it is proposed

to use an inexpensive application which will make it almost fire-proof."

I will add that as yet no strictly unflammable wood has come under my observation. So much as to the rosin process. Use alone can show whether the long searched for problem of the preservation of timber has been solved by it or not. Says our present Commissioner of Patents, the Hon. S. S. Fisher, in a decision lately given in a patent case: "If the means are inferior to the old way of doing the same thing, or inferior to other new ways, the invention sinks into obscurity and is soon forgotten. The best test of utility is use, and in the busy competition of trade this is soon applied, and the judgment of the inventor is affirmed or reversed by an inexorable tribunal."

LETTERS, ANALYSES, &c., OF PROFESSOR DOREMUS,
THE COLLEGE OF THE CITY OF NEW YORK,
June 19th, 1868.

Mr. THEO. WM. HEINEMANN:

Dear Sir,—I have nearly completed the investigation of your process for preserving wood by impregnation with rosin.

I am happy in reporting progress, to state that of the eight samples of wood which you brought for examination, viz.: pine, chestnut, white oak, elm, birch, maple, black ash and spruce, are all thoroughly saturated with rosin.

Six of these have been subjected to chemical analysis, portions being taken from the centre and from the circumference, with the following results—

One cubic foot of fresh	Pine wood	contains.....	8.89 lbs	of rosin.
"	"	" Chestnut	"	 10 "
"	"	dried "	"	 13.5 "
"	"	" Black Ash	"	 4.9 "
"	"	" Maple	"	 2.998 "
"	"	fresh White Oak	"	 15.8 "

The other samples are now being tested.

There is no question, therefore, but that you can completely impregnate the above-mentioned woods, and from these experiments, I conclude that you will be able to accomplish the same result with any variety of wood, by your ingenious process.

The advantages attained by your experiments are:—

That the wood will be permanently preserved from decay.

That owing to filling the pores completely with rosin, which is insoluble in water, foreign matters cannot gain entrance.

That though the pieces of wood are soft and easily worked shortly after saturation, in a few days they become exceedingly hard.

I have never before seen any process which would accomplish such a marvellous change.

Moreover, the apparatus required is not expensive. The process is simple. The rosin costs only about a cent a pound (that is such variety as you require), and but little fuel is necessary to fuse the rosin, and to generate the pressure necessary for impregnation.

I have the honor to remain, Yours, respectfully,

R. OGDEN DOREMUS, M. D.,

Prof. Chemistry and Toxicol. Bellevue Hosp. Med. College,
and Professor Chemistry and Physics, College of City of New York.

THE COLLEGE OF THE CITY OF NEW YORK

July 11th, 1868.

MR. THEO. W. HEINEMANN:

Dear Sir,—I have examined samples of different kinds of wood, impregnated with rosin under pressure, by your simple and ingenious process, with the following results: By chemical analysis of portions taken from the centre, and from the circumference of each block, it was found on an average that a *cubic foot of freshly cut*

Pine wood had absorbed.....	8.39 lbs of rosin.
Chestnut wood " 	10- " "
" " artificially dried, had absorbed	18.5 " "
Black Ash had absorbed.....	4.9 " "
White Oak " 	15.8 " "
Poplar, or White wood had absorbed.....	6.2 " "

While a *cubic foot of old "seasoned"*

Maple wood had absorbed.....	2.99 " "
Spruce wood (10 years seasoned), had absorbed..	1.75 " "
Birch wood had absorbed.....	3.24 " "

In all the above mentioned cases, the sections were thoroughly impregnated with rosin, and they are sufficient in number and variety to demonstrate that any kind of wood, whether "green" or "seasoned," may be completely saturated with this substance by employing your process.

The advantages attained are that the wood will be permanently preserved from decay, for the following reasons:—

The pores of the wood being filled with rosin, will prevent the entrance of water and matters soluble in it, which ordinarily facilitate the decomposition of organic substances.

The woody fibres being entirely coated with this protecting agent, will not be exposed to the oxidizing influences of atmospheric air.

The nitrogenous principles which so readily ferment, having been subjected to a high temperature during the treatment of the wood, and being resinously enveloped, cannot undergo "*eremacausis* or decay."*

Resinous bodies were the most prominent ingredients employed by the ancient Egyptians for preserving vegetable, and the much more putrescible animal tissues. You may therefore justly claim not only that in accordance with chemical principles by your process, wood will be shielded from change, but also that mummified cereal grains, as well as animal and human mummies, are practical demonstrations of a similar protection from destroying agencies, for periods extending over 2,000 and even 3,000 years.

An additional and frequent cause of serious injury to woody tissues, is the destruction produced by worms, against which this rosin process is a protection.

Again, a great advantage is that although the pieces of wood are soft and easily worked by ordinary carpenters' tools shortly after saturation, yet in a few days they become indurated and exceedingly hard, which not only renders the resinized fibres more durable, but makes them available for many other purposes beyond those of the same tissues unimpregnated.

The *simplicity* of the apparatus you employ, as well as the *inexpensive* material used, and the slight cost of impregnation, in comparison with the great advantages resulting therefrom, are such as all capitalists will appreciate.

The variety of rosin you require costs at present less than a cent per pound, and but little fuel is necessary for liquifying it, and for generating the pressure necessary for thoroughly introducing it through all the pores of the wood.

The importance of preserving wood from destroying agencies, is too well known to require lengthened demonstration.

* As to the true causes of the decay of wood, I would refer the reader to the article "*Timber Rot*," in the "*Engineering and Mining Journal*," of July 27th, 1869.—A. Ott.

Dry rot and other influences, so frequently and at times rapidly destructive to wooden ships, to the beams of many of our edifices, to our bridges, railroad ties, etc., etc., which cause annual losses of millions of dollars, and thousands of human lives, are powerful and fearful proofs of the urgent necessity of such potent protecting processes as your valuable invention.

Trusting that you soon may be able to apply it on an extensive scale, I have the honor to remain, Yours respectfully,

R. OGDEN DOREMUS, M. D.,

Prof. Chemistry and Physics, College City of New York. Toxicology, Bellevue Hosp. Md. College.

September 10th, 1868.

Mr. T. W. HEINEMANN:

Dear Sir,—In addition to the statement concerning experiments made with your Rosin Saturated Wood, I should mention that one piece of White Wood, impregnated by your process, and weighing 97·0 grammes, was immersed in water for forty-two days, after which it weighed 98·5 grammes, being a gain of one gramme.

By allowing the water to drain from a few crevices, in the course of half an hour it returned to its original weight.

A piece of the same variety of White Wood, but unsaturated with rosin, and weighing 43·5 grammes, was immersed in water for forty-eight hours, when it had increased in weight to 91 grammes, being more than double its original weight.

These experiments satisfactorily demonstrate that porous woods, capable of becoming thoroughly water-soaked, when impregnated with rosin, after your simple and effective process, can be rendered impervious to water.

I have the honor to remain, Your obedient servant,

R. OGDEN DOREMUS, M. D.,

Prof. Chem. and Toxicol. Bellevue Med. College. Prof. Chem. and Physics, College of the City of N. Y.

SOLAR ECLIPSE OF AUGUST 7, 1869.

(Continued from page 288.)

REPORT OF MR. J. C. BROWNE.

Prof. Henry Morton, Ph. D.

Sir,—Having been requested by you to arrange and make up the chemicals necessary for the use of two of the parties organized in Philadelphia for the purpose of photographing the total eclipse of August 7th, 1869, I made up the following preparations, according to the formulæ given below.

Following the advice given by Mr. Warren De la Rue, in his report on the eclipse of 1860, I used fused nitrate of silver in making up the nitrate bath, in the proportion of 45 grains of silver to the ounce of distilled water, acidulated with 6 drops of nitric acid *CP*. One gallon and a half of filtered silver solution was allowed to each party, carefully packed in two-gallon demijohns in separate boxes. One gallon of distilled water being included in each box, also, extra silver, in case of accident. Five glass dipping baths, holding 20 oz. of solution each, were thought to be sufficient,—each bath enclosed in a wooden box, with a cover to exclude light and dust, and hard rubber dippers coated with paraffine.

Various samples of collodion were made up, but none gave such excellent results as the following mixture:

Alcohol.....	1 Pint.
Ether.....	1 Pint.
Cotton	4 gra.

Excited with

Iodide of Am.....	5 gra.
Bromide of Mag.....	2½ gra.

Developing solution was made in the proportions of 80 grs. of Proto Sul. of Iron to the ounce of water. No acid was added unless desired for immediate use. The solution was then reduced to the strength of 20 grs. of Iron to the ounce of water, and the addition of 2 drams acetic acid, No. 8, to each ounce.

Cyanide of Potassium was used for fixing, and a liberal allowance of chemicals was included with each out-fit, also, Collodion vials, funnels, filter-paper, brushes, &c.

All the articles were packed in boxes with the name of the respective telescopes marked upon the outside.

I was stationed at Ottumwa, with the section of Prof. Himes, and took charge of the coating of the plates, while Mr. Baker developed them. Our chemicals all worked in the most satisfactory manner.

No re-development was necessary. In most of the exposures the picture came up almost too rapidly, rendering it necessary to have cold water close at hand to check further action. To gain time during the development of so many negatives, after the image was all out upon the plate it was washed slightly and placed in a bucket of water containing a few pinches of chloride of sodium. During the Eclipse, after totality, as many as 8 or 10 plates were placed in the bucket at one time, collodion side towards the inside, afterwards the plates were washed and fixed.

A lot of dilute glycerine had been prepared, but the above plan seemed to answer very well. All the plates were numbered with a diamond and dipped with the number always in the same position.

SOLAR ECLIPSE OF AUGUST 7, 1869.

REPORT OF MR. O. H. WILLARD.

Prof. Henry Morton, Ph. D.

Sir,—Having been requested by you to take charge of the photographic preparation and work for the High School telescope, placed in charge of Prof. A. M. Mayer, at Burlington, Iowa, I made the following arrangements:

The plates and plate-holders being $4\frac{1}{2}$ inches square, I first adjusted the camera so as to secure an image of the sun $2\frac{1}{4}$ inches in diameter, and then, by repeated trial, found the best actinic focus; adjustment being made by moving the entire eye-piece and camera toward and from the objective, by means of the regular rack and pinion belonging to the telescope. Bringing the eye-piece nearer to the objective shortened the focus of the combination, and was thus equivalent to a withdrawal of the sensitive plate. The distance between the best visual and actinic foci was about $\frac{5}{8}$ of an inch.

I had the requisite chemicals prepared according to the following formulæ.

BATH.

Fused Nitrate of Silver.....	45 grs.
Distilled water	1 oz.
Nitric Acid	5 drops to the gallon.

Iodized by immersing an 8 by 10 plate flowed with the following collodion:

COLLODION.

Ether.....	1 oz.
Alcohol	1 oz.
Cotton (Pyroxyline)	10 grs.
Iodide of Ammonium.....	10 grs.
Bromide of Potassium....	4 grs.

DEVELOPER.

Protosulphate of Iron.....	6 grs.
Water.....	$\frac{1}{2}$ gall.
Acetic Acid No. 8.....	4 oz.

FIXING SOLUTION.

Hyposulphite of Soda.....	4 oz.
Water.....	1 quart.

The exposures during the partial phases were made by the arrangement described in your report, and the smallest slide (*i. e.* that having an opening of $\frac{1}{4}$ of an inch) was used until the last two pictures, which were exposed with $\frac{1}{8}$ inch opening. Only one spring was used throughout.

Six exposures were made during totality, the first two of 5 seconds each, the last four of 8 seconds each. The plates were prepared by Mr. Phillips and developed by Mr. Mahoney with the assistance of Mr. Leisenring, of Galesburgh.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, September 15th, 1869.

THE meeting was called to order with the President, Mr. J. V. Merrick, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the Minutes of the Board of Managers, and reported the donations received since the last meeting of the Institute:—From the Royal Astronomical Society, the Society of Arts, the Chemical Society, the Zoological Society, the Institute of Actuaries, the Statistical Society, the Institution of Civil Engineers, and C. P. Sandberg, Esq., London; the Literary and Philosophical Society, Liverpool, and the Association for the Prevention of Steam Boiler Explosions, Manchester, England; l'Academie des Sciences and la Société d'Encouragement pour l'Industrie Nationale, Paris, et la Société Industrielle, Mulhouse, France; der Oesterreichischen Ingenieur-vereins, Vienna, and T. C. Winkler, Harlaam, Germany; the Canadian Journal, Toronto, and Major L. A. Huguot-Latour, Montreal, Canada; the Institute of Natural Sciences, Halifax, Nova Scotia; John A. Parker, Esq., Andrew H. Green, Esq., City of New York, the Peabody Institute, Baltimore, Md.; Frederick Emerick, Esq., the Surgeon General's Office, Washington, D. C.; the American Philosophical Society, Dr. W. S. W. Ruschenberger, R. A. Parrish, Jr., Esq., and Prof. John C. Cresson, Philadelphia.

The various Standing Committees reported their minutes.

The Resident Secretary read his report on Novelties in Science and the Mechanic Arts, after which the meeting, on motion, adjourned.

HENRY MORTON, *Secretary*.

On account of its special interest at the present time we here publish the paper read at the succeeding meeting, whose minutes will in regular course appear next month after they have been duly read and approved.—ED.

THE EJECTOR CONDENSER FOR STEAM ENGINES.

(Paper read before the Franklin Institute at its Regular Meeting, Oct. 20, 1869.)

BY JAMES R. NAPIER, F. R. S., &c.

IT is well known that the ordinary jet condenser requires a pump to remove the air, and the water used in condensation. Mr. Alex. Morton, of Glasgow, while experimenting on a Giffard's Injector, discovered that the pump could be dispensed with, that the exhaust

steam itself could do that work, that the steam after forcing its piston to the end of the cylinder had sufficient energy left to take itself, and any air with which it might be combined, out of the cylinder and produce a vacuum equal to that by the best condenser and air-pump of the ordinary construction.

The apparatus which he invented to enable the steam to do this work, and which he calls an Ejector Condenser, is shown in the plates. It is very similar in arrangement and mode of action to a Giffard's Injector. The cold water wanted for condensing the steam, if below the apparatus, is raised by a jet of steam (*a*) in the same manner as in Giffard's or Sellers' Injectors. When the vacuum is formed in the cylinders of the engine this steam jet is stopped by means of the double piston valve arrangement (*b*), and it may be prevented from stopping or be partially stopped by the screw nut (*c*) on the rod of the double piston.

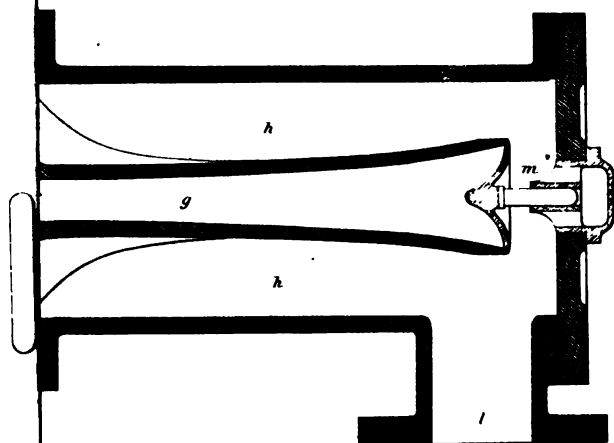
The exhaust steam from one cylinder enters the apparatus at (*c*), and from the other cylinder, if there are two, at (*d*). The condensation takes place at the nozzles (*e*) and (*f*), respectively. The condensed steam, water and air are discharged by the trumpet-shaped tube (*g*) into the chamber or hot well (*h*), surrounding that tube. From the hot well the feed water for the boiler is drawn by any of the ordinary appliances. The rest of the products of condensation is discharged at (*e*). A valve (*m*) at the wide end of the discharge pipe prevents the water in the hot well from being drawn into the cylinders when the engine stops.

Experiments have been made by Professor Rankine, of the University of Glasgow, one of the ablest men for such a purpose, with an Ejector Condenser, on a small double cylinder engine, of about 18-inch stroke, and 10½-inch diameter, made for showing its powers. The results he communicated, in November, 1868, to the Institution of Engineers in Scotland, and very recently, September, 1869, he experimented on an ejector applied to a larger engine pumping water from a coal mine at Dalry, near Glasgow.

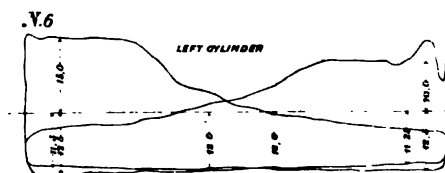
[A copy of this report, the speaker intended to have presented to the meeting, but he had not received it when expected.]

These Ejectors can easily be worked into the design of any new engines intended for condensation, and also with little trouble, added to many existing non-condensing engines where it would be impracticable or too costly now to apply the ordinary jet condenser and air-pump. The saving of fuel, increase of power, decrease of pressure on boiler, or increase of speed of steam vessels, will, no doubt, in such cases, be the same for the same pressure in the condenser by whatever system the condensation is procured. Prof. Rankine has shown, however, that in the engine he experimented upon, in November, 1868, all the power required to work the air-pump was saved.

And although the speaker was not aware of the reasons which have induced American engineers to use so commonly non-conden-



as with Morton's Ejector Condenser, Nov. 1868.



Morton's Patents
31, West Nile Street, Glasgow

Lith by Jas. M. Gagan, Phil^a

sing engines for many of their river boats, he thought that the Ejector Condenser removed the objections of complication, weight, space and deterioration from muddy water, commonly urged in Britain against condensing engines, and if the first cost was the chief objection to condensing engines, Morton's Ejector would evidently cost the manufacturer much less than the common jet condenser and air-pump. But at what rates they would be sold here depended on how the American patent was to be worked.

The selling price in Glasgow, however, of one of these Ejectors for a 10 or a 12-inch cylinder, and having probably a $\frac{1}{4}$ -inch water jet, was about £80 or about \$190 currency.

The theory of the working of Giffard's Injector, as manufactured by Messrs. Wm. Sellers & Co., of Philadelphia, has been so simply explained by Prof. Henry Morton, in the *Journal of the Franklin Institute*, that the speaker had no doubt the same gentleman would be able to satisfy the members of the soundness of the principles on which Morton's Ejector Condenser is based.

It worked well in Great Britain on fast and on slow going engines. on engines with one and on engines with two cylinders. The indicator cards, Plate showing the vacuum obtained during Prof. Rankine's experiments speak for themselves.

Messrs. Dennistoun & Co., of New York, who have the disposal of the American patent have authorized the erection of one of these condensers in that city, and it is expected to be at work in a few weeks.

Observations were made by various gentlemen as follows:

Mr. Robert Briggs said that the invention was undoubtedly an important step in the improvement of the parts of the steam engine, rivaling in its value the apparatus it was based upon, the Injector of Giffard. It should be considered as a further development of the discovery of Mr. Giffard. About nine years since he had the pleasure of assisting in some experiments, instituted by Mr. William Sellers, for the purpose of determining the quantities of water which would be delivered by Giffard Injectors of different sizes, under different pressures and with varying temperatures and lifts of supply water. Very numerous experiments with many sizes of Injectors were made at that time, and when the conditions of temperature and lift of supply water were constant, in place of giving a variation of delivery proportional to the square root of the absolute pressure of steam, or of that of the pressure of the steam above the atmosphere, it had been found that the delivery varied with the square root of the pressure of the atmosphere plus 8 pounds, ($v \propto \sqrt{P + 8}$). This he considered as indicating a partial vacuum of 6.7 pounds tension in the condensing nozzle, and appeared to demonstrate the possibility that with some form of instrument proportioned especially for this end, both that a more complete vacuum would be attainable and that a pressure of steam below the atmosphere might

be made to feed a boiler at working pressure. In other words, the boiler could possibly be fed by the use of the exhaust steam of an engine which it supplied in an Injector. And this function of a partial vacuum demonstrated positively that within the instrument the steam acted independently to the atmospheric pressure, so that this new application is consistent with the results attained by those experiments.

Mr. Wm. Sellers remarked that he had no doubt if the nozzles of the Ejector were properly formed, it would lift water from any depth within the limits of an ordinary suction, or, in other words, atmospheric pressure. His own arrangement of the Giffard Injector, by proportioning the inflow of steam to the capacity of the discharging tubes, accomplished this result.

With regard to slow working engines, he thought there would be no difficulty in keeping up the water jet during the cessation of the steam discharge, providing the water supply or delivery pipe or both were of sufficient length. In his opinion it would be found especially important in this class of engines that the *delivery* pipe should be long, as in that case we should have a large mass of water in motion which would not be checked by a temporary suspension of the impelling force, thus maintaining the vacuum and retaining the water supply in position to condense the successive discharges from the exhaust without having any recourse to the live steam and regulating valve.

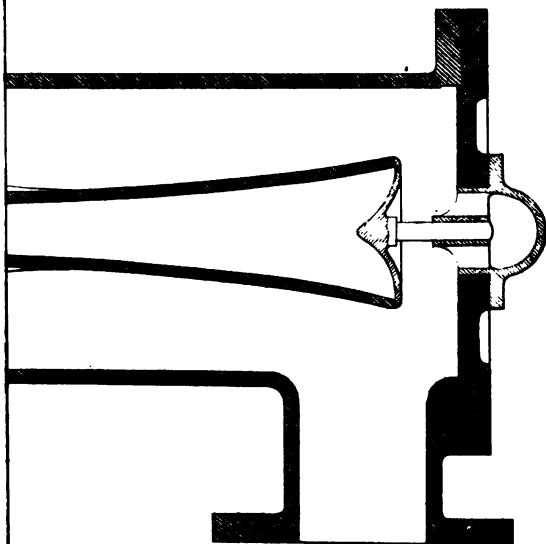
Mr. Thomas Shaw described a plan for ejecting steam, air and water, having some relation to the ejector patented by himself.

In reply to various questions by Messrs. Sellers, Briggs, Shaw, Prof. Rogers and others, Mr. Napier stated that the greatest length of stroke to which he had seen the Ejector applied was the Dalry Engine, reported upon by Prof. Rankine, in September, 1869; it had a $4\frac{1}{2}$ feet stroke, making 20 to 24 revolutions per minute, and a vacuum in the exhaust pipe of about $23\frac{1}{2}$ inches of mercury.

He had seen the first of Morton's Ejector Condenser at the Lugar Iron Works in Ayrshire, it had then been at work about 18 months, and was producing a vacuum of from 8 to 10 pounds. He had not seen the Ejector on any slow-working engines, but Mr. Morton had stated that one was at work on an engine making six revolutions per minute.

That an Ejector was now being made for a pumping engine having a 48-inch cylinder and 9 feet stroke, making 10 strokes per minute. In this case no steam jet is intended to be used, as the cold water comes from a height of about 10 feet to the Ejector. It had not yet been applied to sea-going steamers as a substitute for surface condensers, although it might probably be made applicable by cooling the water of condensation.

Mr. Morton found that the Ejector on single cylinder engines worked best with from 10 to 20 feet of suction pipe, the contained mass of water keeping a steadier vacuum.



*Mortons Patents..
31 West Nile Street, Glasgow*

Lith. by Jas. McGeary, Phil. A.

THE EJECTOR CONDENSER.

MORTON'S PATENT.

Fig. 1.

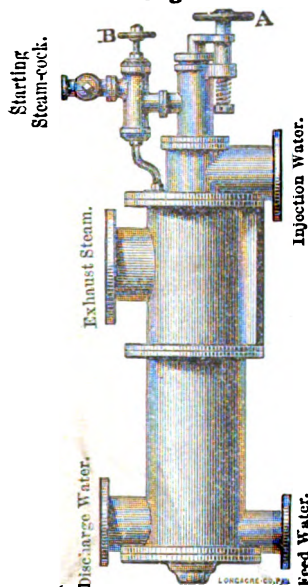


Fig. 1 is for Engines with one Cylinder.

Fig. 2.

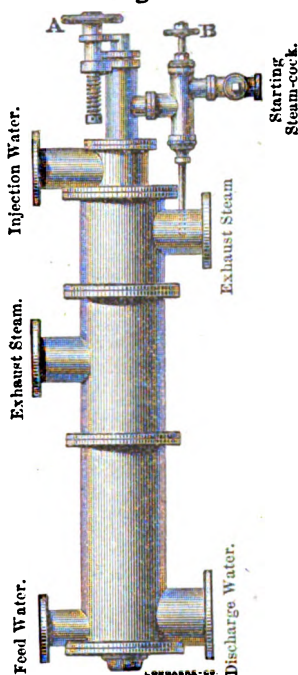


Fig. 2 is for Engines with two Cylinders.

This Ejector Condenser is applicable to all steam engines where sufficient water for condensation can be obtained. It dispenses with the air-pump, saves all the power required for working that pump, occupies much less space than the ordinary jet condenser and air-pump, and has no parts constantly in motion, thus obviating the necessity of skilled attention and frequent repairs: it can be placed on any part of the exhaust steam pipe.

It can be applied to many of the existing non-condensing steamboat engines; it will, with their present consumption of fuel, give about a tenth more speed, or, at the same rate of speed, it will save from 20 to 30 per cent of their fuel with considerably less boiler pressure.

For a description of the apparatus, with report on its efficiency, see the *Journal of the Franklin Institute*, of Philadelphia, for November, 1869.

Reference is also requested to the accompanying testimonials, as to the merits of the apparatus.

The Patentees have placed the sale of the American patent in the hands of the undersigned, to whom application is to be made.

DENNISTOUN & CO.,
No. 22 Exchange Place, New York.

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Science and the Mechanic Arts.

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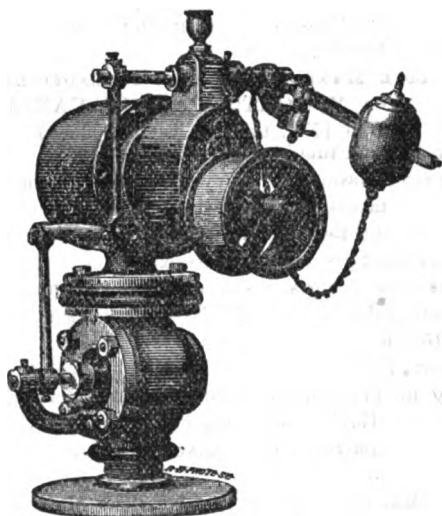
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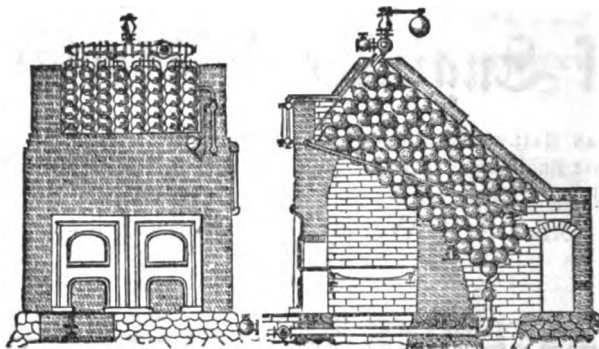
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Mr JOSEPH HARRISON, Jr.

Sir:—In my last communication to you in regard to your six fifty-horse power steam boilers, I promised to give you, at a future time, the exact amount of saving in fuel.

I am pleased to be able to do so now, as I kept a very close and accurate account of the fuel used from December, 1867, to December, 1868, to compare your boilers with the old ones, which we took out in September, 1867.

The amount of raw sugar we refined during that time was larger than ever before. The steam pressure was always kept over fifty pounds, and we were therefore enabled to do more work in a shorter time with the same machinery and apparatus than with our old steam boilers, in which the pressure, at times, could not be kept up higher than twenty to thirty pounds.

The actual saving in fuel, during this time, was one thousand and seventy-one tons of coal.

Yours truly,

GUSTAVUS JASPER, Superintendent.

Worcester, Mass., February 1, 1869.

JOSEPH HARRISON, Jr.

Dear Sir:—After using one of your thirty-one horse power boilers sixteen months, it gives me great pleasure to say that it has proved, in every particular, entirely satisfactory. I have had many opportunities to recommend it, which I have done with pleasure. For economy in fuel, it excels all boilers in use. I can raise steam in shorter time than in any boiler I have ever seen; and would cheerfully recommend it as the cheapest, safest, and most economical boiler ever in use.

Very respectfully yours,

A. N. WHEELER.

OFFICE OF THE GRANITE STATE MILLS,
Newport, N. H., February 1, 1869.

JOSEPH HARRISON, Jr., Esq.

Dear Sir:—Yours of January 9th, asking our opinion of the Harrison Boiler, is at hand. We have had your boiler in use fifteen months, and it gives us perfect satisfaction in quickness of raising steam, and the cheapness of running it, as compared with the old-fashioned boilers. Our boiler does not yet leak a drop, and we do not believe it ever will; and last, though not least, our workmen about it do not feel obliged to get their lives insured.

Yours truly,

COFFIN & NOURSE.

Concord, N. H., February 8, 1869.

JOSEPH HARRISON, Jr., Philadelphia, Pa.

Dear Sir:—Your favor of January 9th came duly to hand. The 62½ horse power boiler, which we had of you in October, has, from the time we commenced its use, until now, given perfect satisfaction, and we can see no reason why it should not continue to do so. It is the only boiler (and we have had a variety of kinds,) that suited us from the first. We save fuel, are troubled with no leakage, and feel safe in using it. We can only say that it meets more than our expectations.

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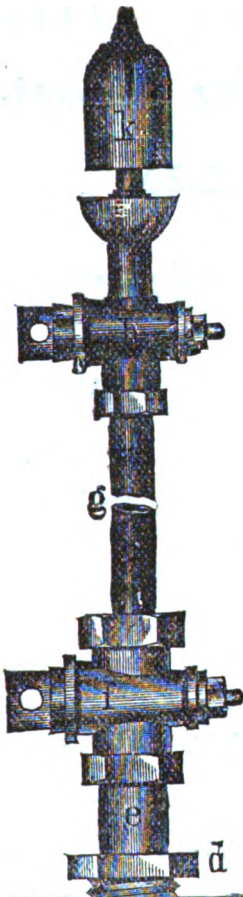
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Yours, very truly,

CHAS. MASON, Late Commissioner Patents.

To HENRY HOWSON, Esq.

Boston, October 12, 1886.

MY DEAR SIR: It gives me great pleasure to give my testimony as to the manner in which you conducted your business as a Solicitor of Patents, during the four years that I was Chief Clerk and Executive Officer of the U. S. Patent Office, and for a considerable period Acting Commissioner.

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Very truly, yours,

JOHN L. HAYES, Late Chief Clerk and Executive Officer U. S. Patent Office.

H. Howson, Esq., Philadelphia, Pa.

Washington, D.C., November

I fully and cheerfully endorse the statement made by Mr. Hayes in the above letter, as Howson to the advantage of the inventors of the country.

D. F. HOLLOWAY, Late Commissioner

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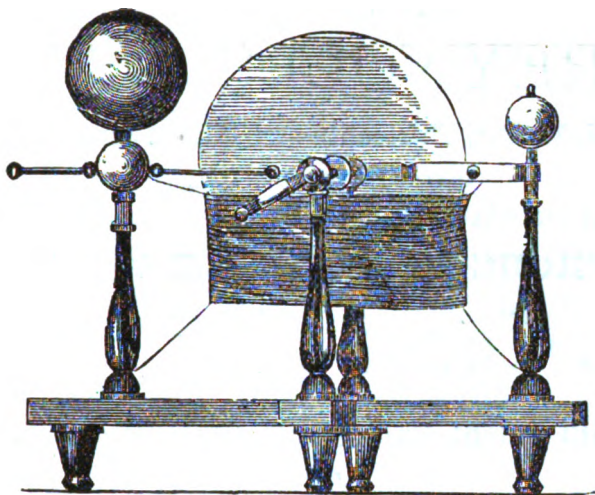
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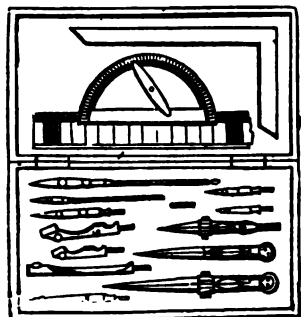
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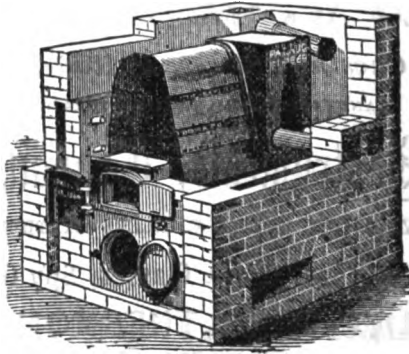
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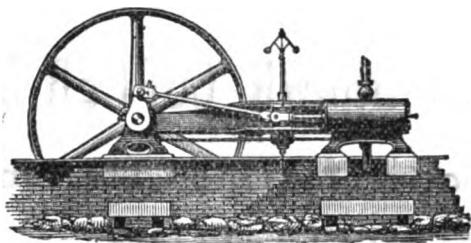
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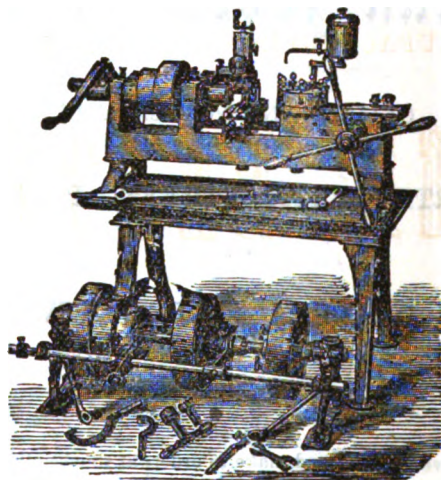
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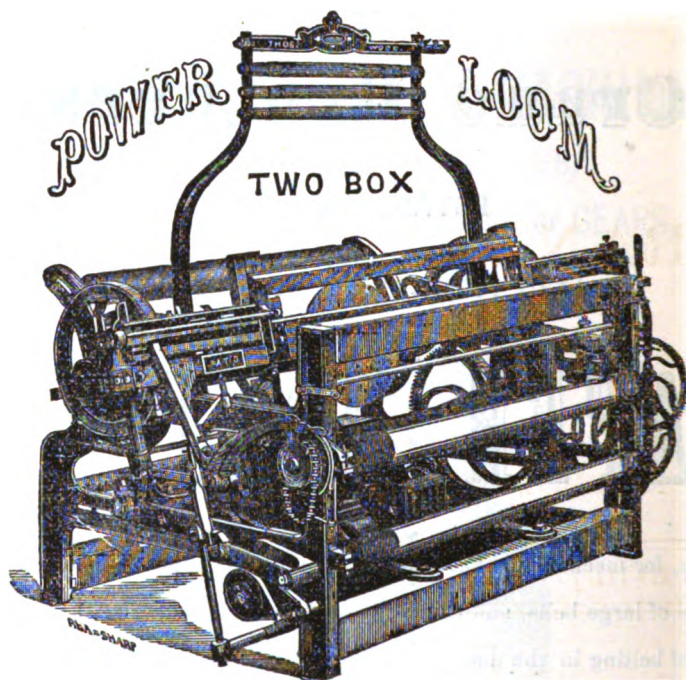
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VOL. LVIII.]

DECEMBER, 1869.

[No. 6

EDITORIAL.

ITEMS AND NOVELTIES.

The New York and Brooklyn Bridge.—The Bridge Company have not yet concluded the negotiations for a site for the Bridge Tower on the Brooklyn side of the river. This tower will be built in the third or upper slip of the Fulton Ferry. The Ferry Company lease their ferry property from the City of New York, and the Commissioners of the Sinking Fund of this city are vested with the power of leasing and selling public property. When negotiations were opened by the Bridge Company to obtain possession of the upper slip and a section of the adjacent land, the Sinking Fund Commissioners referred the matter to a Commission of Estimate and Assessment, consisting of Wilson G. Hunt and Thos. R. Agnew, who have not yet made their report. It is understood, however, that this will be forthcoming without much further delay, after

VOL. LVIII.—THIRD SERIES.—No. 6.—DECEMBER, 1869. 46

which the preparations for the reception of the caisson will be at once proceeded with. Messrs. Webb & Bell, of Greenpoint, have commenced the construction of the caisson, which is to be sunk to the base of the Brooklyn tower of the East River Bridge, and the work is now well under way. Col. William H. Paine is at Messrs. Webb's yard every day superintending the work on behalf of the Bridge Company. It is expected that the caisson will be ready to launch some time in March. It will then be floated to the location of the Brooklyn foundation. The river shore will be dredged out to low water line, and the caisson floated into its position on a high tide; on the water receding, it will be anchored or "seated," and excavating to sink it the required depth will be carried on in its interior. Through the roof will be six shafts, or funnels, made of $\frac{1}{2}$ -inch boiler iron. The two supply shafts through which the workmen descend and ascend, and by which the excavated soil is removed, will be 21 inches in diameter each. Each of the two air-shafts, by which air is supplied to the workmen, is 42 inches in diameter. Each of the two water-shafts, in which the water oozing through the soil will be conducted, so as to keep clear of the workmen, is 7 feet square. On top of this caisson will be piled timber to the height of 15 feet, and the whole mass filled in with concrete, and on this bed of wood and stone will be placed the masonry for the towers. The caisson is in shape a parallelogram, 168 feet long and 102 feet wide on the outside, and is about 15 feet high. The sides are V-shaped, the bottom being 8 inches thick, and the top 8 feet 3 inches, and 10 feet high, and the roof, which rests on three sides, is 5 feet thick. The whole is constructed with yellow pine, a foot square, with the seams caulked. Between the outside layers of timber is a sheathing or layer of tin, between two of felt, intended to prevent the atmosphere from working into the interior of the caisson. The sharp edges of the structure are to facilitate the sinking of the box 30 feet beneath low tide level, and, accordingly, this portion is strongly made. The first layer of timber is of oak; on this is bolted a cast iron shoe, 8 inches wide, oval on its face, being 3 inches thick in the centre. Around the shoe is placed an armor of boiler iron, extending 3 feet above the shoe, on both sides of the wall, the whole strengthened by heavy angle-irons on the interior, 16 feet long. As the pressure of air on the caisson will increase as it sinks, it is estimated that the atmosphere resting on the surface will vary from 18,000 tons to 40,000 tons, consequently, careful

and accurate calculation is made to give strength to the box. The timbers are all bolted together, perpendicularly, horizontally and diagonally, with the heaviest and longest bolts ever used. These bolts are, on an average, 18 inches apart throughout the structure, and the ends are made air-tight by rubber washers. The immense number of bolts may be imagined, when it is expected that 100 tons of them will be used. The interior of the caisson will be a room 166 feet long, 100 feet wide, and 9 feet high. There will be about 1,500,000 lineal feet of timber used in constructing the caisson, and when ready for launching it will weigh 3,000 tons. In order to launch it, there will be seven ways or keels underneath, and a water-tight compartment or air-chamber in the interior, 38 feet wide, extending lengthwise. In addition to this, there are 10 heavy supporting frames to sustain the roof.

New Method of Setting Tires.—A late English patent is for contracting the wheels instead of expanding the tire while the setting is being accomplished: this is done by hydraulic pressure. "As the pressure is applied and the wheel contracts, it is made to descend into a funnel-shaped support, so that when the external pressure is taken off of the rim, the pressure upon the hub, giving dish to the wheel, being still maintained, the contraction of the rim is kept up till the tire is placed around it. The hub being next released from pressure, the elasticity of the wood-work carries the hub back to its normal position. With reference to other parts of the wheel, a general expansion takes place, and the tire becomes permanently set."

A Huge Bridge.—The iron bridge at St. Louis connecting the Illinois and Missouri shores of the Mississippi River, is reported to have been commenced, and 430 men, with all the modern steam appliances for excavating earth and moving heavy stones and timbers are now at work. The bridge structure is to be composed of three wrought and cast iron arches, one of 515 feet in length, the other two 497 feet each. The lower part of the bridge is intended for the passage of railway trains, the upper for ordinary travel.

Steel Fire Boxes for Locomotives.—At a recent meeting of the Master Mechanics' Association, at Pittsburg, Pa., the report of a special committee stated that a locomotive had run on the Northwestern Railroad for eight years with a steel fire-box, which has thus far shown no signs of wear, although the coal and water had proved extremely detrimental to the copper and iron fire-boxes

previously used. Two locomotives on the Pennsylvania Railroad, fitted with steel furnaces in 1861, still remain intact, and about the same time two on the Baltimore and Ohio Railroad were furnished in like manner with the same results. The committee decided emphatically in favor of homogeneous steel plates for locomotive fire-boxes, at least all those that burn bituminous coal; and that for boiler plates for general construction, this material combines in a greater degree than any other requisites of durability, safety and economy.

Annealing Large Cast Projectiles.—The tendency of large casting to burst is well known; the remedy is to provide for homogeneity in the casting. The plan suggested for large projectiles is that followed by the Messrs. Whitney & Sons with their car-wheels, namely, to move the cast projectiles from the chills as soon as the metal has "set" nearly or quite to the core; place them in an oven heated to from 700° to 800°, and suffer them to remain, guarded from oxydation by influx of air or gases, until the gradual lowering of the temperature has brought them to the requisite cool condition. The time required for annealing in this manner a 10-inch solid shot is estimated at from 10 to 15 days. The method is worthy of testing by manufacturers who may have occasion to turn out chilled castings of any considerable size.

The "Mahovos."—We take the following from the report of Mr. Auchincloss, on steam engineering, at the Paris Exposition. "A curious invention has recently been produced by Mr. C. Schouberswky, of St. Petersburg. Its object is to dispense with steep gradients on railways, by the addition of a carriage to each train, which shall act the part of a store-house for momentum developed during a descent, whence it may be reproduced at will, and assist the locomotive on the opposite ascent. He has given the title of 'Mahovos' to this new motor, and introduced a working model in the Russian Department of the Exposition. The track for the same is 110 feet in length, having a rise of 4 feet in this distance. Near its lowest point is a turn-table for reversing the 'Mahovos,' and a tank to receive the water contained in its train of five cars. The model weighs 275 pounds. The drawings accompanying the report show two ponderous fly-wheels, resting by means of rollers upon a central pair of wheels, which run upon the track between two larger truck-wheels. The five cars filled with water are coupled in front of the 'Mahovos' at the top of the grade. When

ready for starting, the two large fly-wheels are lowered until their axle rests on the four friction-rollers, and these in turn on the six carrying wheels on the truck through the medium of four rolls on their shafts. Under the impulse of gravity, the train commences its slow descent, during which a high velocity is ultimately imparted to the fly-wheels. It reaches the turn-table after a lapse of two minutes. At this point the cars, being detached, continue their journey until the tank is reached, into which, having discharged about 800 pounds of water, they are then led back to the turn-table. In the meantime the fly-wheels, with their shaft, are raised out of gear, the 'Mahovos' turned end-for-end, and made ready to re-ascend after the coupling of the cars takes place. This being accomplished, the fly-wheels are lowered a second time, when the cars rise quickly to the starting point.."

Longitudinal Sleepers for Railroads.—The State Engineer of New York says, in his report on railroads: "There is a growing conviction among engineers that the longitudinal system will become standard. It offers from two to three times as much bearing for the rail as the cross-sleeper system. The whole strength of the longitudinal sleeper is added to the strength of the rail, considered as a beam to carry the load, the strength of the cross-sleeper is wholly wasted. The longitudinal is almost certain to prevent the displacement of a broken rail.

Wagon Tongues.—George Alexander, of Romney, Indiana, has invented a device to retard the jarring of wagon tongues. A piece is bolted to the under side of the tongue, to which is pivoted an iron rod; this rod plays into a cylindrical spring attached to the gearing of the fore axle. The rod is threaded to receive a nut which rests against the spring, and can be regulated to keep the end of the tongue at the height desired, thus preventing, in a measure, the jerking of the breast-chains and the jerking of the collars upon the horse's necks.

The Fog-Whistle at Cape Foucher, N. S.—It is said this whistle may be heard 15 miles in calm weather, 5 to 8 miles in storms, 25 miles with the wind, and 5 to 8 miles against the wind.

Arsenic in Carbonate and Sulphate of Soda.—Fresenius finds that arsenic is often present in carbonate of soda. A sample, being purchased as chemically pure, on being mixed with cyanide of potassium, and heated in a stream of carbonic acid gas, gave distinct traces of an arsenic mirror. Five grammes dissolved in water,

and saturated with hydrochloric acid heated to 70°C ., gave clear yellow flocculi with sulphuretted hydrogen. He traces the origin of this arsenic to the sulphuric acid employed in the manufacture, the greater portion of which is now made from arsenical iron pyrites.

Heating Solutions above 212° with Steam at 212° .—In the last number of the English *Chemical News*, which we have received (November 26th), we find an interesting paper by Mr. Peter Spence, F. C. S., in which he describes experiments which led him to the discovery that, if steam at atmospheric pressure and corresponding temperature was passed into solutions of a higher boiling point, it would heat them to temperatures much above that of the entering steam, and, in fact, related to the boiling point of the solutions treated.

Though at the first glance this result seems paradoxical, a little reflection shows us that it is exactly what we should expect from the known conditions.

As every one is aware, steam contains some $1,000^{\circ}$ of latent heat—i. e., to turn one pound of water at 212° to steam at 212° will require as much heat as would raise over 1,000 pounds 1° , or, neglecting accidental conditions of the experiment, 1 pound over $1,000^{\circ}$.

Reciprocally, if steam at 212° is converted into water at 212° , this same amount of heat is liberated.

Now, when steam is passed into water, it rapidly heats it by this cause to 212° , but, after that, will no longer be condensed, and hence will impart no higher temperature, but will simply escape with all its heat still in it.

When, however, the steam enters, a dense solution, such as that of sulphate of alumina, mentioned by Mr. Spence, it may be said to combine with it, diluting it by means of the water so added, but yet leaving a solution which will not be vaporized by the higher temperature thus acquired and which thus retains the added heat.

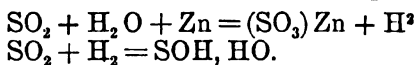
Were it not for the action of the dissolved salt, any rise of temperature above 212° , supposing it to occur from condensation of steam, would cause the formation of a similar amount of vapor, which would reabsorb the emitted heat, and so keep the temperature constant at 212° .

The essential point in this reaction is after all the absorption of the steam by the solution; and while this discovery is of great inte-

rest and value, and a beautiful illustration of the theory of latent heat, we must be careful not to be misled into an inaccurate view of its real significance.

Test for Prussian Blue.—Jerome Nickles found that Prussian blue might be distinguished from the blue of indigo, or aniline, by means of fluoride of potassium, which bleaches it, while it does not so effect the other two.

A New Acid of Sulphur.—Prof. Schutzenberger has discovered an oxide of sulphur, to which he proposes to give the name hydrosulphurous acid, and to its salts hydrosulphites. The formula is SOH, HO. The acid is considerably less stable than its salt, and is produced by the action of sulphurous acid upon zinc.



The liquid resulting from the action of the zinc upon a concentrated solution of bisulphide of soda, with exclusion of air, and in a cooling mixture, is poured into concentrated alcohol, and the flask sealed; immediately double crystals of sulphite of soda and zinc deposit on the side of the vessel. The alcohol is decanted and again sealed up and left to itself, when acicular crystals rapidly form. These crystals rapidly efflovesce, and must be kept hermetically sealed. Their solution decolorizes indigo, litmus, and precipitates hydrate of copper from its sulphate, and silver from its nitrate. Hydrogen separates in a nascent state. The formula for the soda salt of the new acid is $\left. \begin{matrix} \text{SOH} \\ \text{Na} \end{matrix} \right\} \text{O}$, and the free acid would be SOH, HO. As the new acid possesses bleaching properties equal to ozone, further information in reference to it will be looked forward to with interest.

Photographic Exposure Shortened.—In a late number of the *Photographic News*, London, which is, undoubtedly, the best foreign publication of its kind, we notice an interesting paper on the above subject by Mr. William Blair, and an excellent editorial notice of the same.

From these we gather that an increase in rapidity of working in the camera may be obtained by exposing the negative-plates to a little diffused light before or after exposure. The *rationale* of this treatment is, that a certain amount of motion or other change (rendering the film fit to react with the developer) is given to the entire surface, leaving but little more to be done by the localized

lights of the picture in order to cause a deposit to take place with the developer, while, at the same time, this general action is not sufficiently decided to produce any effect without this added action of light, thus leaving the dark portions unaffected, although they are thus brought to the very verge of reaction.

Protective Coating for Small Metal Articles.—Capt. Ross, of the English artillery, has obtained letters-patent for a composition which, applied to the clean surface of iron and other metals, chemically combines with it to form, in the case of iron, a coating of iron itself, but changed in character, so that it will not rust or oxydize, even if steeped in water for a week. Experiments were made on some delicate steel articles, by putting them in the rain and keeping them out on wet grass all night, which ordeal they sustained without gaining a speck of rust. It is hard to say what trade will not profit by this discovery. The composition can be applied to the finest needles and small clock-wheels. It is said to improve the temper of knife or sword-blades.

Working of Plaster of Paris.—When 2 to 4 per cent. of finely-pulverized althea root (*marsh mallow*) is mixed with plaster of paris, it retards the hardening, which begins only after an hour's time. When dry, it may be filed, cut or turned, and thus become of use in making domino-stones, dies, brooches, snuff-boxes, &c. 8 per cent. retards the hardening for a longer time, but increases the tenacity of the mass. The latter may be rolled out on window-glass into thin sheets, which never crack in drying, may be easily detached from the glass, and take on a polish readily by rubbing them. This material, if incorporated with mineral or other paints, and properly kneaded, gives very fine imitations of marble, and can be colored when dry, and can be made water-proof by polishing and varnishing. The chemist and chemical manufacturer will find it an excellent luting for vessels of every kind.

The Albotype.—The London *Photographic News* thus describes the process: "A plate of glass is covered with a solution of albumen, gelatine and bichromate of potash, dried, and exposed to light until hardened. It is then again covered with a solution of gelatine and bichromate of potash, and, when dry, exposed under the negative, and the film is then found to possess qualities analogous to a drawing made with fatty ink upon lithograph-stone. All those portions of the film that were acted upon by the light will refuse water and take printing-ink, while those portions which were pro-

tected from light by the negative will take water and refuse ink. The ink and water will be absorbed by the film just in accordance with the gradations of light and shade in the negative. To produce a picture, wet the surface of the film, then apply ink, lay on paper, and pass through a press: the operation being substantially the same as lithography. The process is said to be rapid, and excellent pictures, of all sizes, may be printed in admirable style."

California Silk.—We have received from Mr. William J. Horstman a beautiful specimen of raw silk raised in California by Mr. D. Prevost, of San José, and reeled on a machine invented by Mr. Joseph Neuman, of the same place.

This material is of an excellent character and in perfect condition, forming a solid hank of the beautiful golden color peculiar to the best raw silk. We learn that much is being done in California by the gentleman on whose estate this sample was produced, as well as by others, and it will evidently be of great advantage, if an industry which represents, yearly, a sum of \$214,900,000 can receive such encouragement that it may be fairly established in our country, where so large a demand for its products does and always must exist.

In France, this industry has grown, under governmental protection, from a yearly aggregate of \$5,000,000, in 1812, to \$140,000,000 in 1860.

Removing Gum from Silk.—A French patent makes known the fact that the removal of gum from silk may be more easily and cheaply obtained by the use of ammonia than by the usual method of boiling with soap.

Percentage of Water in Alcohol.—A simple test of percentage of water in alcohol is to pour a little chloroform into a graduated glass tube, and a given volume of the spirit to be tested is added, and both well shaken up together. On settling, all the water will be found to have separated from the alcohol (which has combined with the chloroform), and may be read off on the graduated tube.—*Artizan*.

Explosive Power of Dynamite.—Experiments with dynamite, under the direction of M. von Arx, gave proof of its extraordinary explosive power. Two and a half cartridges detached a mass of $6\frac{1}{2}$ cubic meters of hard rock in a bore-hole of 1.11 meters depth and 3 centimeters diameter; and three and a half cartridges in a hole 1.32 meters depth, loosened a mass of seventy-one cubic meters.

New Mode of Sharpening Files.—M. Wedermann's plan is to clean the files as usual, and then place them in connection with the positive pole of a battery, in a bath composed of 40 parts of sulphuric acid, 80 parts of nitric acid, 1,000 parts of water. The negative pole is formed of a copper spiral surrounding the files, but not touching them; the coil terminates in a wire which rises toward the surface; 10 minutes is generally sufficient, when they are taken out and washed, and then the operation is repeated, if necessary.

Separation of Animal from Vegetable Fibre.—Mr. James Stuart, of 40 Ropemakers' Fields, Limehouse, has invented a new process for separating animal from vegetable fibre. He subjects the rags, carpet-cuttings, old carpets, and other waste material of mixed fibres, to a solution consisting of 100 gallons of hot water, 100 pounds of commercial sulphate of alumina, and 50 pounds of chloride of sodium. In this solution the material is kept boiling until the vegetable fibre is decomposed or rotted; the material is then well washed and dried, and scribbled or carded.

Electro-Plating with Iron.—C. M. Clay & Co., of New York City, have patented a galvano-plastic process for electrotyping and plating with iron from a bath composed of the sulphate of iron combined with the sulphate of ammonia, potash or soda.

New Use for Glycerine.—Herr Kolb proposes to add from 1 to 3 per cent. of glycerine to wine to reduce to the smallest possible limits the tendency to change, which all wines, from their inner nature, possess.

Quick-Drying Varnish.—Twelve parts of shellac and four parts of borax, added to one hundred parts of water, carefully heated while the mixture is continually stirred, soon completes a solution which is colorless, or brown, according to the color of the shellac employed. This solution forms a varnish perfectly impermeable to water, and not acted upon by the atmosphere. It can be used with oil-paints, to make them dry quickly, by adding an equal part of the varnish, with a little turpentine, to the oil-colors, and rubbing them together until a homogenous fluid mixture is obtained. This mixture dries in from ten to fifteen minutes, and hence a small quantity must be prepared at a time.

Ornamental Glass may be produced, by vitrifying variously-colored glass in powder on the surface of articles of glass or glazed ware, the fragments being attached preliminarily by some gummy or other adhesive liquid.

Chlorate of Potassa as a Blow-Pipe Test.—In the *Neus Jahrbuh fur Pharmacie*, M. Landauer enumerates instances in which chlorate of potassa may be made useful before the blow-pipe. This salt gives up at higher temperatures some of its oxygen to certain metals, and becomes itself colored from the oxides of those metals. From iron and its compounds it receives a flesh color; from lead a brown; from copper a shade of light or dark blue, in some cases even so deep as to be nearly black. Manganese imparts a purple of variable intensity, and nickel (sesquioxide) turns it to black.

Another Explosive.—"The Lithofracteur" is the name of a new explosive material, invented by Mons. Krebs, of Deutz, and recently the subject of experiments on a large scale at Cologne. The ingredients are kept secret. The advantages claimed are greater power than nitro-glycerine, small production of smoke and perfect safety.

Great Telescopes.—M. De la Rue is having a lens constructed of 13 inches in diameter. Prof. Henry Draper has very nearly completed a new silvered glass reflector of 28 inches in diameter, the largest of the kind yet constructed, except one by Fourcault. With this instrument the original negatives of the moon will be taken 6 inches in diameter, with provision for extending them to $9\frac{1}{2}$ inches if desirable.

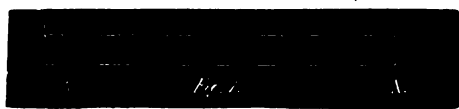
Prof. Draper expects thus to obtain photographs of larger size than any that have been produced. There is now being erected at Melbourne, Australia, a powerful reflecting telescope 4 feet in diameter, of Cassegrain form, which will be supplied with the necessary apparatus for photography as well as for spectroscopic investigation.

Another Asteroid.—On the night of the 9th ult., Dr. C. H. F. Peters, the astronomer, of Litchfield Observatory, Hamilton College, discovered a new planet, the ninth to his credit.

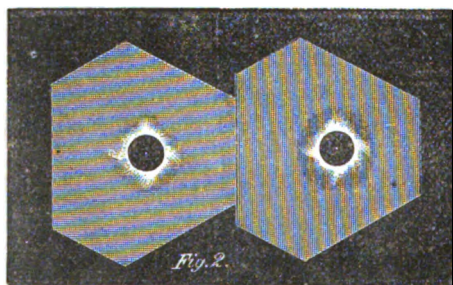
Dr. P. writes thus, the next day, to the *Ulica Herald*: "A new planet was discovered here last night about midnight. It belongs to the asteroids, and will bear the number 109 of that group. From repeated measurements the position resulted, for half-past one o'clock fourteen degrees and one minute in right ascension, and nine degrees thirty-seven minutes in north declination, with a rapid motion almost parallel to the equator. Its brightness is equal to that of a star of the tenth magnitude, and it has just past its opposition with the sun."

Lead Pipes with a Tin Lining.—A new way of manufacturing lead pipes, with a lining of tin, has been devised by M. J. Grand, Jr. The object is to run the lead in the mould first, and allow the tin to follow while the former metal is still liquid. A rapid movement of rotation keeps the two metals from mixing while a perfect junction is formed as they solidify.

- ① **Note on the Supposed Polarization of the Corona.**—By Prof. E. C. Pickering.—An observation on this subject is given in my report on page 285 of the current volume of this *Journal*, but as the form of the instrument used has been in one or two cases misunderstood, I enclose a sketch of it.



A B (Fig. 1) is a sheet-iron tube, closed at A with a plate of quartz and at B with a prism of Rochon. The latter has the property of giving two images of any object seen through it, separated by an angle of nearly 3° . Looking through the tube we therefore see two images of the quartz touching, but not overlapping. When the light is polarized these images assume complementary tints, which vary with the plane of polarization and the thickness of the quartz. On turning this instrument towards the sun during totality, the images presented the appearance shown in Fig. 2.



The hexagons represent in form and size the plate of quartz; the black circles the moon, here drawn a sixth of an inch in diameter, as the scale is about 3° to the inch. The corona appeared white, but the sky surrounding it was colored in one image blue, in the other, yellow,—represented in the figure by vertical and horizontal lines. The conclusion to be drawn from this is, that the light of the corona is unpolarized, or, more strictly, that the amount of polarized light, if any, is too slight to be perceptible with this instrument. Its delicacy, although not equal to Savart's polariscope, is very great, giving colored images with paper, wood and other bodies which reflect a small amount of light specularly. The day before the eclipse it showed, in a very marked manner, the polarization of the wet pavements and roofs. To measure its

sensitiveness, I viewed the light reflected by a piece of plate glass, at different angles of incidence, and found that the color ceased to be visible when this angle was about 10° , which, allowing for the reflection from the second face would give about one part of polarized to twenty-four of natural light.

Observers heretofore have generally attached their polariscope to a telescope, and thus introduced a source of error, avoided in my instrument. For, light passing through the object-glass and field lens, would be polarized by refraction before reaching the polariscope by the obliquity of the incidence, caused both by the curvature of the surfaces and the fact that the edge of the field of view receives its light not parallel to the axis. The plane of polarization would be perpendicular to a plane falling through the axis of the instrument. Now, if any part of the corona was brought into the centre of the field of view, the adjoining portions would appear polarized in planes parallel to the edge of the field, or passing through the sun's centre. In sweeping around the sun's edge the plane of polarization would continually change, as the corona passed through different parts of the field, and the comparative darkness of the moon's disk and the exterior sky prevent the polarization of the other portions of the field from being visible. The degree of polarization by refraction would be very slight and perhaps imperceptible, but the agreement of observation with this hypothesis is certainly a curious coincidence.

The strongest argument against the polarization of the corona is furnished by the spectroscope, the presence of bright lines and absence of dark ones, as observed by Prof. Young, denoting incandescence, a view strengthened by the consideration that each square centimetre of the surface of the corona would receive several thousand units of heat per minute. I am well aware that my results are at variance with those obtained by previous observers, including some of the most eminent astronomers of the day, but as far as I can learn this form of polariscope has not been used for the purpose, and therefore hope that my experiment may be repeated during the next eclipse.

Cause of Bright Line on Partial-Phase Eclipse Pictures.
By Prof. Henry Morton.—During the progress of the Eclipse of August 7th, I observed on the negatives, taken during the partial phase by the section of my party with which I had located myself, a decided increase in the opacity of the silver deposit in immediate contact with the advancing edge of the moon. When, after our

return to Philadelphia, all the negatives taken by the other two sections were handed over to me, I found the same characteristic appearance, varying only slightly in degree, to distinguish all of them, and this had, of course, been noticed by those engaged in making the pictures. In fact many remarks have been made upon this point, and some deductions drawn from it.

On the paper prints prepared from these negatives, this local density produced a line of light in contact with the moon's limb.

An appearance similar to this, had been observed by Prof. Alexander, in the photographs taken during the eclipse of 1860, as also by Mr. De la Rue, and while ascribed by Prof. Challis and Prof. Alexander to a very rare lunar atmosphere, had been explained by Mr. De la Rue and the Astronomer Royal, as a subjective effect.

The Astronomer Royal had, moreover, shown, in papers published in the *Monthly Notices* of the Royal Astronomical Society, 1863, Nov. 13, and 1864, June 10, that no such effect would be produced by a lunar atmosphere, were it present. He, therefore, very justly discards such a supposition, and by satisfactory experiments shows that the light line in the prints under his examination is an optical illusion and not an existing fact.

These experiments, however, when applied to good prints of our pictures, did not show the same result, and, beside, the actual opacity of the negatives seemed to preclude the above explanation as one accounting for the entire effect.

I therefore made the following experiment:—I converted one of the solar pictures, taken soon after first contact, into a crescent, by pasting partly over it a dark circular piece cut from another print. This showed a faint line of light such as results from contrast, and which was no doubt found in the pictures examined by the Astronomer Royal.

I then had this artificial eclipse-picture photographed, (through the kindness of Mr. James Cremer) when negatives were produced showing a dense deposit along the lunar edge, and giving prints which showed a bright line in the same place far more decided than that seen in the artificial original.

It thus appears that the effect observed in these eclipse pictures, while not due to any lunar inflection of sunlight, is also not due to an optical effect of contrast solely, but is in great part due to a chemical action which may be explained by what we know of the chemical reactions concerned in the production of a negative.

It is well known that the development of a negative depends upon the presence of free nitrate of silver in the film, and that a great strengthening or intensifying may be produced by re-immersion in the silver bath, and a second application of the developer. Now, in the present case, part of the plate representing the dark edge of the moon, and therefore not acted upon, furnishes a reservoir of nitrate of silver, imbibed by the collodion film, which, during the development, penetrates for a short distance into the portion representing the *luminous* area of the sun whose supply of free nitrate was exhausted by the reaction which occurred at the first moment when the developer was applied.

My conclusion, then, is, that while a certain effect in the paper prints is, and was on former occasions, due to "contrast," yet in the present instance the peculiar appearance of the negatives, and most of that seen on the prints, is the result of a chemical action such as I have described, and does not represent any celestial phenomenon. The *appearance* of a bright line in the same place which has been noted by several observers is, we believe, due simply to the contrast of the sharply defined lunar edge, which produces the faint line above mentioned, in the artificial eclipse-picture before described.

Editorial Correspondence.

TELLURIUM ORES IN THE UNITED STATES.

*Cabinet of Practical Geology and Mining,
General Land Office, Washington, D. C., Nov. 6th, 1869.*

Prof. Henry Morton, Ph. D.

Sir:—I take the liberty to send the following for publication in the *Journal of the Franklin Institute*.

All the tellurium minerals formerly known in mineralogy, with the exception of the sylvanite or graphic tellurium, have been found in Calaveras and Toulumne counties of California, together with several new species—the calaverite, a tetratelluride of gold, and the melonite, a sesquitelluride of nickel. Amongst some fragments from Highland, Montana Territory, sent to this office, Dr. Genth discovered a new mineral, the "Montanite," a tellurate of

bismuth, associated with the pure telluride of bismuth or tetrady-mite. The second variety of tetrady-mite, that containing sulphur besides the tellurium, has been recognized by him on a broadly foliated specimen received at this office from "Uncle Sam's Lode," near Helena, Montana. It is associated with the new mineral, "Montanite" quartz, and minute quantities of tourmaline; it contains 5 per cent. of sulphur, corresponding with the formula: $\text{Bi S}_3 + 2 \text{Bi Te}_3$. The yellowish mineral with waxy lustre (the montanite) is a product of the oxidation of tetrady-mite, and is a hydrous tellurate of teroxide of bismuth. The ore is very rich in gold, and it is claimed to yield, by assay, \$100,000 per ton of 2,000.

The native tellurium is distinguished by its nearly tin-white color and metallic lustre. It contains no silver and no gold. The tellurite of gold and silver found in the Stanislaus mine, Calaveras Co., California, exhibits some singular appearances, differing, at the same time, from the tellurite of silver-gold found in Nagyag and Offenbanya, Transylvania, in its physical and chemical properties. Both the tellurite of silver-gold, and the tellurite of silver, contain some silenium. The tellurium reaction of that mineral on charcoal, and in glass tubes, is less characteristic than of the like mineral from Transylvania; but the reaction in treating the ore in a tube with soda and charcoal-powder is very intense.

The analysis of tellurides of silver-gold from Transylvania, and from the Stanislaus mine, is as follows:—

Stanislaus Mine (Blowpipe Analysis).

Tellurium	35.40
Gold	24.80
Silver	40.60

Specific gravity from 9.0 to 9.4.

Transylvania (Analysis by Klaproth).

Tellurium	60.60
Gold	30.60
Silver	10.60

Specific gravity from 5.7 to 5.8.

The Stanislaus mine has been worked to a limited extent, the shaft being only a little over 200 feet deep. The ore is found in layers of quartz, talcose, slate, and lime-spar, extending, sometimes, to a considerable width, and for many feet in length, and is, generally, very rich.

Yours, very respectfully,

A. R. ROESSLER.

Civil and Mechanical Engineering.

MORTON'S EJECTOR CONDENSER.

[Report of Experiments with the Ejector-Condenser on engines at Albert Works, Glasgow.]

BY W. J. MACQUORN RANKINE, C. E., LL. D., F. R. S., &c.

IN accordance with our promise in the last number, we here reprint Prof. Rankine's first report, to which reference was there made.

(1.) The Ejector-Condenser, invented by Mr. Alexander Morton, was applied to a pair of vertical inverted direct-acting steam engines, which exerted collectively a power averaging about 24 indicated H. P. The nominal power of these engines is collectively 7 H. P., if we apply the ordinary rule for low-pressure engines, or 15 H. P. if we apply the ordinary rule for high-pressure engines. The dimensions of the engines and of the condensing apparatus, and the results of the experiments, are given in detail in the annexed table; but as regards the engines, it may be convenient to state here that their two cylinders were of 18-inch stroke, and about $10\frac{1}{4}$ inches diameter, that they ran at from 93 to 140 revolutions per minute, and that the steam-pressure gauge indicated from 30 to 40 lbs. on the square inch above the atmospheric pressure, which, at the time, was 14.75 lbs. on the square inch. It may be remarked that the experiments throw light on other questions besides the efficiency of the new Condenser; and, in particular, that the accurate measurement of the quantity of condensation-water, and of its change of temperature, affords the means of calculating the total expenditure of steam, and comparing it with the quantity of steam effectively used in doing work, as indicated by the diagrams.

(2.) The circumstances under which the experiments were made were, to a certain extent, unfavorable to the apparatus; for the pipe which supplied the tank from which the cold water was drawn for condensing the steam was of too small diameter; and the engines had, from time to time, to be stopped, in order that the tank might be re-filled. It is desirable that a second series of experiments should be made with a cold-water supply pipe sufficient to fill the tank faster than the condensing apparatus empties it. The rate at which the cold water was expended was ascertained by observing on a vertical scale the rate at which the level of the water sank in the tank when the supply pipe was closed; and in this important measurement my own observations were checked by those of Mr. James Brownlee.

(3.) The principle of the invention may be described as follows: In every injection-condenser the cold water rushes into the vacuum with a velocity of 43 or 44 feet per second, or thereabouts. The

exhaust steam rushes from the cylinders into the condenser with a velocity which is many times greater than that of the water. In the common condenser those rapid motions of the water and of the steam are completely checked, and their energy is wasted in agitating the fluids in the condenser, and ultimately in producing heat; and hence it becomes necessary to use an air-pump in order to extract the water, air, and uncondensed steam from the condenser. The power expended in working a well-proportioned and well-constructed air-pump is known, by experiment, to be equivalent to that which would overcome a back pressure on the steam-piston of from $\frac{1}{2}$ lb. to $\frac{3}{4}$ lb. on each square inch of its area, or on an average about 0.6 lb. on the square inch; and that amount of power is lost through the wasting of the energy with which the jets of water and steam rush into the condenser. In the Ejector-Condenser the motion of those jets meets with no interruption; and its energy is found to be sufficient, without any assistance from pumps, to carry all the water, air, and uncondensed steam, if any, completely out of the condenser and into the hot well, and thus to save the power which would be required to drive an air-pump.

(4.) The principal parts of the condensing apparatus on which my experiments were made may be summarily described as follows: The cold water passes from the tank to a conoidal nozzle; the area of the orifice of that nozzle is about equal to that of the injection sluice of a common condenser suited for the same engine—that is to say, about $\frac{1}{16}$ th part of the collective area of pistons. Enveloping the cold water nozzles are a second and a third nozzle of nearly similar figure: these bring the exhaust steam from the two cylinders respectively. The middle nozzle has an orifice a little larger than that of the innermost, or cold water nozzle: the outermost nozzle ends in a throat or contracted vein, a little larger still, beyond which is a gradually widening trumpet-shaped mouth-piece leading to a pipe which ends at the hot well.

The condensation of the steam takes place in this interval between the orifice of the cold water nozzle and the throat of the outermost nozzle.

(5.) The completeness and efficiency of the condensation were tested by vacuum gauges and by indicator diagrams. By both means of testing, the left-hand cylinder, which exhausted into the middle nozzle, showed a rather better vacuum than the right-hand cylinder, which exhausted into the outermost nozzle. The average results of the whole of the experiments were as follows:—

Mean vacuum shown by gauges, in inches of mercury.....	24.6
Do. do. in lbs. on the square inch.....	12.0
Mean vacuum in cylinders during return stroke, as shown by the indicator diagrams, lbs. on the square inch.....	10.7
Which, being subtracted from the atmospheric pressure at the time.....	14.75

Leaves, as the mean back pressure in the cylinders during the return-stroke, in lbs. on the square inch..... 4.05

The back pressure, in different experiments, ranged between 3 and $4\frac{1}{2}$ lbs. on the square inch. These results are at least as good as the average results as to vacuum and back pressure obtained by means of the common condenser; and they show the condensation of the steam and expulsion of the water, air and vapor, to be at least as complete and efficient.

(6.) I have estimated the saving of power through the dispensing with an air-pump as being equivalent to the doing away with a resistance of 0.6 lb. per square inch area of steam-pistons, and I find it to be, on an average of the several experiments, just one horse-power: being about $\frac{1}{4}$ per cent. of the mean indicated power of the engines.

I have calculated the energy of the jet of cold water, and I find it to be about $\frac{1}{4}$ of a horse-power. This forms the greater part of the energy which is wasted in the common condenser, rendering an air-pump necessary.

(7.) The experiments, then, so far as they have gone, lead to the following conclusions:—

First. That the action of the Ejector-Condenser is at least as efficient as that of the common condenser, with its air-pump; and

Secondly. That by the use of the Ejector-Condenser the power required to drive the air-pump is saved.

(8.) I have already mentioned one circumstance in the experiments, which was disadvantageous to the apparatus, viz: the insufficient size of the supply pipe of the cold water tank. Another disadvantageous circumstance was the absence of jacketing and of superheating; for, unless one or other of those means be employed, a considerable quantity of steam condenses in the cylinder when first admitted, and re-evaporates during the return-stroke, thus at once carrying heat from the boiler to the condenser without performing work, and injuring the efficiency of the condenser.*

I have calculated, as the Tables show, the total quantity of steam expended from its effect on the temperature of the condensation water, and it proves to be, on an average, about *two and a-half times* the quantity which performs work in the cylinder, as calculated from the indicator diagrams. When applied to engines that are free from this defect, it may confidently be expected that the new condensing apparatus will give, as regards vacuum and back pressure, results surpassing even the very good performance which has been described.

* On this subject, reference may be made to papers by Mr. Brownlee and myself in the *Transactions of the Institution of Engineers in Scotland*, for 1860-61.

TABLE OF EXPERIMENTS

Made on the 27th day of October, 1868, on a pair of Engines at the Works of
Messrs. Neilson Brothers.

CYLINDERS.

Area of each, allowing for piston-rods, about.....80 sq. ins.
Stroke.....1.5 foot.

COLD-WATER NOZZLE.

Diameter..... $1\frac{3}{8}$ " = 0.8125"
Area.....0.638 sq. in. = 0.00443 sq. ft.

WATER TANK.

Area..... $8' \times 8\frac{1}{2}' = 28$ sq. ft.
Mean depth of surface below level of nozzle.....5.25 feet.

WASTE-WATER NOZZLE.

Diameter of throat..... $1\frac{1}{4}$ " = 0.9875"
Area of throat.....0.690 sq. in. = 0.00479 sq. in.
Diameter of mouth-piece.....3.0"
Area of mouth-piece......7.07 sq. ins. = 0.0491 sq. feet.

COLD-WATER SUPPLY.

	Cubic feet.	Pounds.
Mean rate of flow per minute.....	$28' \times 0.41 = 11.48$	= 716.4
Mean rate of flow per second.....	0.1918	= 11.94
Velocity of cold water through nozzle, feet per second.....	$3\frac{1918}{80644} = 43.2$	

	Feet.	Lbs. per sq. in.
Head due to that velocity	29	= 12.57
Add mean height to which water is lifted.....	5.25	= 2.275
Total head	34.25	= 14.845

Temperature.....47° Fahr.
Mean work per minute done in raising and propelling water-jet, exclusive of friction... $716.4 \times 34.25 = 24537$ ft. lbs.
= 0.744 I. H. P.

BAROMETER.

30.05 inches mercury = 14.75 lb. on the square inch.

SETS OF EXPERIMENTS.	A	B	C	D	E
	Right Hand Cylinder.		Left Hand Cylinder.		
Nos. of diagrams.....	1	{ 2·8 4·5	6	7·8	9
Revolutions per minute.....	180	93	abt. 140	107	108
Steam-gauge above atmosph., lbs. on the square inch.....	{ 34	from 82 to 88		35	from 40 to 30
Do. do., absolute.....	48·75	{ fr. 46·75 to 52·75		49·75	fr. 54·75 to 44·75
Vacuum-gauges bel. atmosph., lbs. on the square inch*.....	{ 12·08 11·54	12·4 12·1		12·3 11·8	
Do. do., absolute.....	{ 2·72 3·21	2·85 2·65		2·45 2·95	
Mean back pressure.....	4·25	3·12	4·50	4·38	4·00
Absolute pressure of release....	10·75	10·80	8·75	12·00	10·50
Initial absolute pressure.....	42·75	38·25	32·75	42·75	42·75
Mean effective pressure.....	15·25	14·83	9·85	16·78	15·90
Mean absolute pressure.....	19·50	17·95	14·35	21·16	19·90
Temperature of waste water, (Fahrenheit).....	86·5°	80·5°		88·0°	91·0°
Elevation of temp., above cold water.....	39·5°	33·5°		41·0°	44·0°
Heat carried off by water, Bri- tish units per minute.....	28298	23999		29872	31522
Velocity of pistons, ft. per min.	390	279	420	321	324
Load of one piston, lbs.....	1220	1186·4	788	1342·4	1272
Indicated work, one cylinder, ft. lbs. per minute.....	475800	331906	330960	430910	412128
Do. do., two cylinders.....	951600	662012	661920	861820	824256
Indicated horse power.....	28	20	20	26	25
Indicated work per min. re- duced to equivalent quantity of heat.....	1238	858	858	1116	1068
Total expenditure of heat, Bri- tish units per minute.....	29531	24857		30488	32590
Efficiency of engines.....	0·042	0·035		0·037	0·033
Volume of steam exhausted, as shown by indicator, in cubic feet per minute.....	433	310	467	357	360
Volume of 1 lb. in cubic feet..	35	35	43	32	36
Weight of steam shown by in- dicator in lbs. per minute....	12·4	8·9	10·9	11·2	10·0
Temperature of steam at end of stroke (Fahrenheit).....	197°	197°	187°	202°	196°
Total heat per lb. of that steam from temp. of waste water....	1087	1093		1086	1082
Heat of condensation of steam indicated.....	13479	9728		12163	10820
Heat carried off by waste water (as before).....	28298	23999		29872	31522
Actual expenditure of steam in lbs. per minute, as calculated from the heat of waste water.	26·0	22·0		27·0	29·1
Proportion in which steam ac- tually condensed exceeds in- dicated steam.....	2·10	2·47		2·41	2·91
Work in ft.-lbs. per min. saved by dispensing with the air- pump, estimated as equiva- lent to 0·6 lb. pressure per sq. inch of steam piston.....	37440	26784	40320	30816	31104
Do.. indicated horse power.....	1·13	0·81	1·22	0·93	0·94

* First result is for left hand, and second result for right hand engine.

ABSTRACT OF PRINCIPAL MEAN RESULTS.

Mean power saved by dispensing with air-pump, indicated H. P.	1.0
Mean indicated H. P. of engines	23.8
Mean back pressure in cylinders, lbs. on the sq. inch	4.05
Mean vacuum in cylinders, do do	10.7
Mean vacuum shown by gauges, do do	12.0
Do. do do in inches of mercury	24.5
About two-thirds of the indicated power were due to the vacuum in the cylinders.	
Temperature of the cold water	47° F.
Mean temperature of waste water	83½° F.
Mean increase of temperature	36½° F.

The Condenser was about 5 feet above the tank from whence the water was drawn, so that the water had to be lifted to that extent. In calculating the pressure due to the velocity *plus* that of 5 feet of water, the sum was found to be a little greater than the atmospheric pressure of 14.75 lb. upon the inch. This must have been caused by the impulse of the steam aiding the atmospheric pressure in accelerating the jet.

(Signed) W. J. MACQUORN RANKINE.

BELTING FACTS AND FIGURES.

By J. H. COOPER.

(Continued from page 316.)

WE take pleasure in presenting the following facts contributed by Alexander Bros., manufacturers of Oak-Tanned Leather Belting, 412 North Third Street, Philadelphia.

"It is conceded by all practical men, that oak-tanned slaughter leather is the best material for belting, and as inferior stock such as *chemical* tanned and hemlock leather, colored in *imitation* of oak, by means of quercitron, sumac, &c., is largely used in the manufacture of belting, purchasers should be cautious, in buying, not to get any but pure oak-tanned leather.

"The strongest part of belt leather is near the flesh side, about one-third the way through from that side. It is, therefore, desirable to run the *grain* side on the pulley, in order that the strongest part of the belt may be subject to the least wear.

"In order to prove the above assertion we split, in our machine, a strip of ordinary belt leather exactly in the middle of its thickness, and then subjected each half to a breaking tension, which gave the following results:—Grain side half broke under a direct strain of 468½ lbs. Flesh side half sustained 740½ lbs.

A part of the grain side half is of the same kind of fibre as that of the flesh side, and as the "grain" extends but about one-fourth the way through a hide, much of the strength of the grain half in this experiment is due to the flesh part adhering to it.

"The flesh side is not liable to crack, as the grain sometimes will do when the belt is old, hence it is better to crimp the grain than to stretch it.

"Another important reason for running belting with the grain side on the pulley, is to get greater driving power, that being the smoothest side, it will hug closer, is less liable to slip, and will drive 30 to 35 per cent. more than if run the other way, and if the pulley is covered with leather, grain side out, there will be still greater friction. Therefore a belt will do more work and wear longer on a leather-covered pulley than on any other.

"Belts should *not* be soaked in water before oiling, and penetrating oils should but seldom be used, except occasionally when a belt gets very dry and husky from neglect, it may be moistened a little and then have straits or neats-foot oil applied. Frequent applications of such oils to a new belt renders the leather soft and flabby, thus causing it to stretch and making it liable to run out of line. A composition of tallow and oil, with a little resin or beeswax, is better to use. Whitaker's castor oil dressing is good, and may be applied with a brush or rag while the belt is running."

We select the following from the excellent practical treatise on *Mill Gearing*, by Thomas Box, published by E. & F. N. Spon. London. 1869.

"In the table below, the cases of failure are particularly instructive; column 11 shows that in all the cases failure might have been expected. Thus, No. 1 required a 10½-inch double leather belt, where a 6-inch gutta percha one failed to do the work. In No. 2 a larger pulley was substituted, a 7-inch double leather belt should have been used, and the 6-inch gutta percha one did the work badly. No. 4 failed with a 9-inch single belt to do the work for which a 14 inch single or a 7-inch double belt was required. No. 6 required a 10-inch single or a 5-inch double belt, and failed to do the work with a 6-inch single belt. No. 8 required a 13-inch single or 6½-inch double belt and failed with an 8-inch single belt. It will be observed that in cases Nos. 1 and 11 the difficulty was overcome by using larger pulleys; and in cases No. 4, 6 and 8 by converting the single belt into a double one. Circular saws and some other kinds of machinery require extra strength of belt, as shown by No. 18.

"The rules and tables we have given apply strictly to *leather* belts only; leather is in every way the best material, and is not likely to be permanently superseded by the new materials,—gutta percha, india rubber, &c.

"The table shows that the power of a gutta percha belt 1½ or ¾ inch thick is from 25 to 50 per cent. greater than that of a single leather one. We found in practice that leather belts bear about 310 lbs. per square inch of section, and we may allow that gutta percha will bear about 400 lbs. From direct experiments the cohesive strength of gutta percha is 15 cwt. or 1682 lbs. per

Driving Power of Pulleys, from Cases in Practice.

No.	Nominal Horse-Power.		Diameter of Pulleys.		Distance between Shafts.		Belt contact on smallest Pulley.	Speed of smallest Pulley.	Particulars of Belt.			REMARKS.
	Driver.	Driven.	Feet.	In.	Feet.	In.			Folds.	Width.	Material.	
1	5	2	6	8	8		-446	80	Open.	6	Gutta-percha.	Failed entirely; pulleys made larger, see No. 2.
2	7	3	6	8			-424	80	"	6	"	Badly; required resin, and gave trouble.
3	10	2	5	80			-472	165	"	6	"	{ Drove well; circular saw, 3' 6" diam.; same engine as No. 1.
4	12	7	0	32	53							engine as No. 1.
5	12	7	0	32	58				Crossed.	9	Single leather.	Failed; strap altered to double one, see No. 5.
6	6	5	0	9	40		-5	36	"	9	Double "	Drove well.
7	6	5	0	9	40		-5	40	Open.	6	Single "	Failed; strap altered to double one, see No. 7.
8	18	12	3	6	20		-424	152	"	6	Double "	Drove well.
9	18	12	3	6	20		-424	152	"	8	Single "	Failed; strap altered to double one, see No. 9.
10	18	6	1	3	19		-457	770	"	6	Double "	Drove well.
11	3	1	2	0	12		-49	90	"	6	Gutta-percha, 1/4" thick.	Drove, but not well; same engine as No. 8, &c.
12	3	2	0	12	48		-48	90	"	6	Single leather.	Failed; pulleys made larger, see No. 12.
13	20	9	5	0	16		-467	65	"	9	"	Drove well.
14	12	10	8	0	16		-43	113	"	9	Double "	Drove well; pulleys logged with wood.
15	12	8	4	9	11		-478	100	"	8	"	Drove well.
16	12	10	8	0	14		-42	133	"	6	"	"
17	10	6	4	5	14		-6	49	Crossed.	7	"	"
18	10	4	2	2	11		-6	463	"	4	"	"
19	10	8	5	0	20		-476	64	Open.	9	"	Drove well; extra strong for 4' 6" circ. saw.
20	6	7	8	6	13		-46	106	"	5	Gutta-percha.	Drove well.
21	6	9	8	6	11		-416	128	"	5	Do. 1/4" thick.	"
									"	5	Single leather.	"

square inch, as shown by subjoined table, which also gives the extensions by different weights. It will be observed that with weights greater than 3 cwt. per square inch the extensions increase rapidly, showing that the material is overstrained. The table gives the mean result of two experiments.

Strain per square inch in cwt.	Length.	Extension per cwt.	Strain per square inch in cwt.	Length.	Extension per cwt.
1	1·007	·007	9	1·100	·0111
2	1·014	·007	10	1·120	·012
3	1·021	·007	11	1·142	·013
4	1·029	·00725	12	1·182	·0152
5	1·040	·008	13	1·210	·0161
6	1·051	·0085	14	1·265	·0190
7	1·064	·00914	15	1·287	·0192
8	1·075	·00937	No. 15 broke.		

BLACKFRIARS BRIDGE.

WE take from *Engineering* the following interesting account of this work, just finished. After describing the history and final decrepitude of the former bridge, the author says :—

“The corporation of the city determined upon removing the old bridge altogether, and replacing it by one which should lack nothing in convenience and magnificence.

“The necessary measures having been taken for sanctioning this step, the corporation invited the submission of competitive designs; and, at first, that prepared by Mr. Thomas Page was selected, after a long discussion upon the design of Mr. Brunlees, which was warmly advocated. Mr. Page’s design was for a bridge of three spans, with two piers, and would have been a far nobler work than even his bridge at Westminster. Subsequent to this decision, it was considered advisable to adopt a bridge with five arches, corresponding to the number of openings in the adjoining bridge of the London, Chatham Railway Company. Upon this Mr. Page’s design was abandoned in favor of the one by Mr. Cubitt, which was finally accepted, the estimate being £269,000. Three hundred thousand pounds has been raised for this purpose out of the Bridge House Estates, the property left in ancient times for the maintenance of old London bridge, and which had been augmented by land purchased in the reign of Edward VI., in St. George’s Fields as well as

by the subsequent additions in the City of London, Southwark and the eastern suburbs of the metropolis.

"On the 11th of August, 1863, the first pile of the temporary bridge was driven, and within eight months the structure was completed. It is a magnificent work of its class, and reflects the highest credit upon its designer, Mr. F. W. Bryant, the contractor's engineer. The bridge was built in two floors or storeys, so as to afford the greatest accommodation to carriages and foot-passengers, with the least expenditure of space and material. The structure is 290 feet in length, and the foot-ways are 16 feet above the level of the carriage-road. The lower floor (26 feet) is the same width as the carriage-road of the old bridge; the footways above are each 9 feet wide, or 2 feet greater than the sidewalks of the old bridge. With the exception of the three 70-foot openings for the accommodation of the navigation, which are spanned by wrought-iron girders 6 feet deep; the whole structure is of timber. About 800 piles support the platform, placed 18 feet apart, longitudinally, and 7 feet apart transversely, the whole being braced and strutted, until the bridge represents a perfect forest of timber. In consequence of the high level of the footways, the approaching gradients were necessarily heavy for the upper story traffic, being 1 in 10 on each side of the bridge. The gradients for the carriage-way approximated to that of the new bridge, namely, 1 in 40. For five years this work has admirably performed its duties, and would, of course, continue so to do for a lengthened period. Its annual cost of maintenance has been about £930.

On the 8th of June, 1864, old Blackfriars bridge was closed, the traffic was permanently diverted, and the work of demolition went on immediately and with rapidity, the masonry being first broken on the second arch from the Surrey side. The staging and general plant for this portion of the work had necessarily for the most part to be available afterwards for the re-erection, and its design, therefore, presented unusual difficulties. A row of piling was driven on each side of the old bridge, and about 110 feet apart transversely, a third row being carried midway on the bridge itself, thus reducing the bays to 55 feet. Amply strutted and tied together these piles supported on their upper ends, and at a height of 58 feet above low water, longitudinal timbers which carried rails of 40 pounds to the yard, and upon which the travelers ran to and fro. The gantry thus erected had a breadth about 30 feet greater than the width of the new bridge, so that not only could that structure be constructed within its limits, but ample room was left for the transference of material from the lighters to their ultimate positions. As the work of demolition proceeded the central piles were gradually lengthened from below until they ultimately took their bearing in the river-bed. The steam travelers, which had a clear span of about 55 feet, were supported at the ends by the carriage which ran upon the gantry. They consisted of two wrought iron girders, between

which a shaft ran from end to end, and carried gearing which actuated the wheels of the travelers, being driven by a horizontal engine and vertical boiler. The upper flange of the traveler girders carried rails upon which ran a small carriage fitted with pulleys over which chains were passed from below to a drum worked by the engine before mentioned. Within three months from the commencement of the work, the extensive staging was completed and the bridge well nigh demolished, in which operation the stones were detached one by one, picked up by the travelers, from which they were transferred upon lighters, a secure centering having been fixed beneath each arch before it was touched.

The contract undertaken by Messrs. Thorn & Co., extended from the north abutment of the bridge to 180 feet along Chatham Place, and on the southern side from the face of the abutment to 170 feet along Albion Place.

The following are the dimensions of the clear openings and the width of the piers:—

From face of north abutment to No. 1 pier, 155 feet.			
"	"	No. 1 pier	" No. 2 " 174 feet 5 inches.
"	"	No. 2 "	" No. 3 " 186 " 5 "
"	"	No. 3 "	" No. 4 " 174 " 5 "
"	"	No. 4 face of earth abutment,	155 " 0 "
Width of No. 1 pier..... 18 feet 2 inches.			
"	"	No. 2 "	20 " 6 "
"	"	No. 3 "	20 " 6 "
"	"	No. 4 "	18 " 2 "

The new approaches join the existing road levels at the points of the commencement of the contract. At each end of the bridge on the north side, the road is made in a concave curve, with an average rise of 1 in 43·40. On the south side the approach is likewise on a concave curve, with a rise of 1 in 40. These gradients change about 120 feet from the face of the abutments on both sides, and the road surface, the cornices, and the parapets follow a curve of 68,450·5 feet. At 370 feet on each side of the abutment this curve again changes, and joins in a curve of 3992 feet. To follow this varying curve of the roadway, and to give the central rise of the bridge in accordance with the design, the levels of springing of the arches change with each span to the centre as follows:

At the abutments the springing level is 5 feet above T. H. W.			
At the 1st pier	"	"	6·31 " " "
At the 2d "	"	"	9·06 " " "

The rise and clear headway above high water of the several spans are as follows:

		Rise		Clear Headway.	
		Feet.	Inches.	Feet.	Inches.
1st opening.....	11	7½	.....	17	8
2d "	13	10½	.....	21	6
3d "	15	11½	.....	25	0

Each pier was enclosed by a series of dolphins connected by booms, which extended from above the new bridge on the north side and round the cylinders of the London, Chatham and Dover Railway Bridge down the river. A part only of this work was included in the contract of Messrs. Thorn & Co. The dolphins were framed with three and four piles according to their position. Those of three piles were of 13 inches $\times$ 13-inch timbers, with crossed bracings 13 inches $\times$ 6 $\frac{1}{2}$ inches, bolted with 1 $\frac{1}{2}$ inch bolts. From top to bottom $\frac{3}{4}$ inch diameter chains extended, upon which the booms were free to move. The booms were of four squared timbers 2 feet 1 inch on a side, bolted together by 1 $\frac{1}{2}$ inch bolts, the heads and nuts of which were countersunk into the timber.

The cofferdams of the abutments consisted of two tiers of sheet piling, of which the timbers were 13 inches square, having a space of 5 feet in width between the inner and outer row. The latter consisted of short piles, the heads of which extended only a short distance above the ground, and were driven down into the clay. The inner rows reached to a little above high water, and were driven to a depth of about 37 feet below Trinity high water mark. The space between these two rows was well packed with puddle, and the inner inclosure contained an area 110 feet long by 50 feet wide. This area was divided longitudinally into seven bays by horizontal struts, which abutted upon a central row of piles, that were driven at equal intervals along the whole length of the cofferdam. There were three rows of these horizontal struts, from front to back of the dam, and three rows at similar levels extended up and down its length. This arrangement of dam applied, however, only to the southern abutment, the northern having been built in a single dam.

At the rear of the dam the earth was sustained by a row of sheet piling, kept in place by the system of strutting. The joints between the main piling of the dam were caulked to a depth of 16 feet below high water, and after the completion of the work the outer row of short piles were drawn and the inner row cut off near the ground.

The method pursued in the construction of the piers presented many features of novelty, and has been generally described already in our columns. Each pier stands upon six independent caissons of wrought iron, four of which are rectangular, and the two inner ones are curved to correspond with the contour of the cutwater, beneath which they are placed. In the middle piers the caissons are of larger size, but the construction is identical throughout. The lower or permanent sections of the cutwater caissons are made with an outer iron skin varying from $\frac{3}{4}$ inch at the bottom to $\frac{1}{2}$ inch at the top, two of the sides being curved to the outline of the cutwater with a radius of 24 feet 8 inches, the other or inner side being flat. The skin is stiffened by vertical rolled I-irons 6 inches deep, and placed at intervals of 2 feet. These also serve as a means for joining the outer skin, the plates of which are secured to them. The

whole is strengthened by horizontal curbs, placed 4 feet apart in the upper part of the caisson and 2 feet apart at the bottom. In the cutwater caissons the curb is made of three girders, two curved to the proper form and 18 inches deep, and one straight girder 2 feet deep. The ends of all the girders are mitred so as to unite, and are joined at each angle by one inch bolts, a space being left in each case to admit the introduction of a hard wood packing. In the rectangular caissons, which are 18 feet wide by 36 feet long, the construction is similar; the curbs are, however, only 18 inches deep, and consist, like the others of ordinary plate girders, the top and bottom flanges of which are 9 inches $\times$ $\frac{1}{2}$ inch, with angle irons 4 inches $\times$ 4 inches by $\frac{1}{2}$ inch, and the web $\frac{1}{2}$ inch thick; the latter are strengthened by angle iron stiffeners 2 $\frac{1}{4}$ inches $\times$ 2 $\frac{1}{4}$ inches $\times$ $\frac{1}{4}$ inch, placed at intervals. Midway of the greater length of these caissons was placed a lattice stiffening girder, 13 feet 8 inches long and three feet deep. The top and bottom flanges are of angle iron 4 inches $\times$ 4 inches by $\frac{1}{2}$ inch, and the lattice bars are also angle irons. As at the junction of the curb-girders a space was left for packing at the ends of this stiffening girder. The curbs were secured in place with wrought iron clips on one side of the flange, and cast iron blocks on the other, or a length of timber was substituted for the latter, which is driven between the flange of the curb and an angle iron above. At the bottom the caissons are stiffened with a plate and angle iron 4 inches $\times$ 4 inches $\times$ $\frac{1}{2}$ inch, rivetted to the outer skin 8 inches from the lower edge, a second angle iron of the same dimensions being secured to the I beams, which are chamfered off to a sharp edge at the ends. The height of the lowest section of the caissons is 18 feet, that of the upper and temporary lengths was 7 feet. At the union of the different lengths a water-tight joint was secured in the following manner. The top of the lower length, and the bottom of the one superimposed on it, were made with sills of angle iron 4 inches $\times$ 4 inches $\times$ $\frac{1}{2}$ inch; to these were secured plates with rounded corners, the surfaces of which were truly planed. Two thicknesses of india rubber were then laid upon the planed plate on top of the bottom length, and the corresponding plate of the upper length took a fair bearing upon the rubber. Bolts, $\frac{3}{4}$ inch in diameter and 12 inches apart, fastened the lengths of the caisson together through the angle irons. Mallet's buckled plates were used in the upper temporary lengths of the caissons instead of the flat plates employed below; these were $\frac{3}{4}$ inch thick, and formed the only important difference in construction to the lower sections. The six caissons forming the foundations of each pier were placed in position with an interval of 3 feet between each, and they were lowered in the following manner: Guiding piles were first driven, and then by aid of the overhead traveler the caisson was lowered into its proper place until its cutting edge rested on the bottom of the river. The ground enclosed within the area was then excavated, and by weighting the

caisson was gradually forced into the ground. As soon as the clay was reached, leakage from the river into the caisson ceased, and the latter being drained by Woodford's centrifugal pumps, the work of excavation was carried on until the ultimate depth was reached, and the caisson, by protracted loading, took its final bearing. It was expected before the commencement of the work that the caisson would have to be sunk to an average depth of about 47 feet below T. H. W.; but in the case of the No. 1 pier—that nearest the Middlesex shore—it was found that ground into which the caisson had to be lowered had been scoured out so deeply by the action of the Fleet that unforeseen difficulties arose, and the depth of the caisson had to be greatly increased, to the considerable delay of the work. In No. 2 pier the permanent portion of the caisson is 23 feet high, and it is filled in to a depth of 15 feet, with concrete in cement, upon which is placed 8 feet of brickwork, also set in cement. In the other piers the permanent portions of the caissons are 18 feet high, the concrete filling 10 feet thick, and the brickwork 8 feet as before. In all cases the upper edge of the caissons which now are incorporated in the bridge is 4 feet below low water, and in the course of construction, when the brickwork within the caisson was carried up to the top surface, small pile and puddle dams were placed across each 3 feet space between the different sections, the ground dredged out to the level of the bottom of the foundation, the void being filled with concrete in cement, an uninterrupted area was obtained, upon which the masonry of the piers was laid, the movable portions of the caissons being removed piecemeal as the work proceeded.

The abutments are founded upon concrete of varying thickness, according to the nature of the ground. On the top of the concrete at the face of the abutment is placed 3 feet of brickwork, above which rise the courses of the granite facing, the front of the abutment being built with a curved batter of radius of 200 feet. At the point of the arch springing the thickness of masonry and brickwork is 12 feet backed with 30 feet of concrete. The brickwork itself is strengthened by counterforts 18 feet deep and 8 feet wide. The granite used in the abutments, and indeed throughout the bridge, is remarkable for the evenness of its color and texture, and the size of its blocks. The greater part was obtained from the De Lank quarries near Bodmin, in Cornwall, and is the same material as the largest blocks in the Southern Thames Embankment. About 150,000 feet were used in the abutments and piers, and principally in blocks of great size, 80 of them varying from 12 to 20 tons in weight, and some 200 of them from 6 to 10 tons. There are eight courses in the abutments to the springing of the arch, two 3 feet 8 inches deep, two 2 feet 5 inches, and the rest 2 feet. The skew-backs are 6 feet in two courses, the stones of which are cramped with double cramps at each joint, and joggle-jointed to the courses above and below them. The main pedestal of the abutment is sur-

rounded with a granite blocking course 2 feet 3 inches thick, and the level of which is 38 feet 6 inches above Trinity High Water. Upon this it was intended to place the elaborate bronze statuary, which formed a conspicuous feature in the original design, but which, from motives of economy, the Corporation think it advisable not to proceed with at present. Beneath the blocking course of a highly carved capital of Portland stone forms a highly ornate feature in the abutment; it is 5 feet 3 inches deep, and rests upon the granite pedestal. Subsidiary capitals of the same character crown the piers, against which the parapet of the bridge on the one side, and the parapet of the retaining wall on the other, are finished. A third capital also of the same nature, and on a level with the top of the spandril filling of the girder forms a terminal to a heavy projection, arising from the skew-backs. Along Chatham Place on the north, and Albion Place on the south, the parapets of the abutments extend and terminate in a pedestal of Portland stone with truncated conical head, which will carry a cluster of ornamental lamps.

On each side of each abutment is a causeway of an average length of 122 feet and 19 feet wide, running down into the river at a steep slope. Each are paved with stone upon a curved foundation of Barrow line concrete, the sides being protected with sheet piling of American elm 10 inches $\times$ 5 inches, main piles 10 inches $\times$ 10 inches being driven at intervals of 8 feet. A horizontal timber is bolted on each side of the causeway to the street piling by $1\frac{1}{2}$ inch bolts and at every 8 feet a through bolt of the same diameter ties the main piles together. At the face of the abutment the street piling turns at right angles to the causeway and finishes against the abutment. The river steps leading from this level to the street are in three flights with intermediate landings.

The piers are 130 feet long over the cutwater and of the widths given above. Like the abutments, they are built of brick, faced with the De Lank granite, and relieving the end of each pier, from the top of the cutwater, spring short, but massive columns of polished red granite from Mull. The shafts of these columns are only about 12 feet in height and 7 feet 6 inches diameter. Each of them is formed only of three stones, and the shafts stand on Portland stone pediments, while richly ornamented capitals of the same material surmount them. Into the carving of the capitals has been introduced a profusion of flowers, birds and weeds corresponding with the ornaments upon the abutments. Above the capitals rises the parapet 3 feet 9 inches high, broken at the piers from the straight line to recesses some 10 feet deep and 13 feet wide, accommodated with granite seats.

The spaces between the piers are spanned by wrought iron ribs, of which there will be nine in each span; the upper part of these ribs consist of straight, and the lower of arched girders, the former meeting the latter at the crown, and the spandrils being occupied

with a cast iron lattice filling. In construction all the ribs are alike, but the face girders have cast iron mouldings bolted to them. In getting the ribs into position no complete centres were employed, supporting piles being driven at intervals to support each girder as it was got into place, so that when the cross-bracing was introduced, the keys and wedges driven between the piles and the ribs could be struck and the arch cleared with less expense and trouble than if centering had been employed. The flooring of the bridge is made with Mallet's buckle plates fastened to the road bearers with $\frac{3}{4}$ inch bolts; these being asphalted are covered with a formation of broken stones and asphalt, and upon it is placed the granite pitching of the roadway and the landings of the foot-paths. The cast iron parapet, 3 feet 8 inches high, is highly ornamented, and is designed in the Venetian-Gothic style with vertical openings.

The following are the names of the persons principally concerned in the design and construction of the new Blackfriars Bridge: Mr. Henry Carr, of 4 Victoria street, Westminster, Mr. J. Cubitt, 6 Great George street, Mr. Pickett, Clerk of the Works. The contractors are Messrs. Thorn & Co., their engineer, Mr. F. W. Bryant, President of the Society of Engineers; the iron-work was supplied by Messrs. Lloyds, Foster & Co.; the main portion of the granite was obtained from Mr. C. Goodyear, of the De Lank quarries, and the sculptor who executed the whole of the carvings upon the bridge is J. P. Phillips, Esq., of Hans Place, Chelsea.

The Nile to be Explored in Earnest.—Sir Samuel Baker, at the head of 1,700 men, is to seek the sources of the Nile. The baggage, stores and merchandise, to be used in trade with the natives, have been sent on in advance. Engineers, shipwrights, ten steamers and thirty sailing-vessels, will accompany the expedition. Vessels will be built on the spot for the navigation of lake Albert Nyanza. The expedition will rendezvous at Khartsum, at the confluence of Blue and White Niles, and proceed along the latter as far as it is navigable.

A Portable Brick Machine has been invented by C. A. Winn, in which the clay is tempered by passing steam through it. The bricks are delivered from the molds hot, which facilitates their drying.

Sulphuric Acid is manufactured at the works of C. Tennant & Co., by decomposing a mixture of nitrate of soda and chloride of sodium. The nitrous acid is absorbed by concentrated sulphuric acid, and the chlorine is utilized for the production of chloride of lime.

Mechanics, Physics, and Chemistry.

NEW METHOD FOR THE SEPARATION OF THE PLATINUM METALS.

BY PROF. BUNSEN.

(Translated from his late contribution to the "*Annalen der Chemie und Pharmacie*," entitled "*Ueber das Rhodium*," by W. H. Wahl.

IN the metallurgic process of extracting platinum from its ores, there is obtained three products, which are admirably adapted for obtaining those rare metals which constantly accompany this metal. These products are,—

1. The "Ore Residues," which remain behind after the mass of platinum, &c., has been extracted by aqua regia; these are rich in osmium and iridium, hence best adapted to the purpose of extracting these metals.

2. "Osmiridium," obtained by mechanical washing from the first residue and which is best adapted for obtaining ruthenium.

3. The "Mother-Liquid Residues," left behind in the aqua regia solutions after reduction with iron, the platinum having previously been separated (with chloride of potassium?) These are rich in palladium and rhodium, and are the best for obtaining these metals.

The following researches were made with a material of the last sort; for each separation a kilogramme of residue was used.

The residue contains, with the exception of osmium, all the platinum metals, and is particularly interesting on account of its relatively great richness in rhodium.

Claus' mode of separation (the only one previous to this) involves the loss of much valuable material. To separate the rhodium from iridium, Claus used the old method proposed by Wallaston, which depends upon the solubility of the ammonium (or potassium) double salt of sesqui-chloride of rhodium in chloride of ammonium. The fact, however, that the salt $KCl, IrCl_2$, is taken up in considerable quantity by a solution of chloride of ammonium (or chloride of potassium,) saturated with a rhodium double salt, a fact of which I have repeatedly convinced myself, is sufficient to awake the gravest doubts as to whether the metal given out to be rhodium, and to which Berzelius and Claus ascribed the atomic weight = 52, did not contain considerable quantities of iridium. I found it, there-

fore, necessary to leave the beaten track, and to search for a more exact method of separation.

Separation of Platinum and Palladium from the other metals of the group.

The complete separation of rhodium, iridium and ruthenium from platinum and palladium, by digestion with aqua regia, will not succeed with these questionable residues, as considerable quantities of the first named metals are present in the form of hydrated sesquioxides, and partly present in a most finely divided state, and in consequence, dissolve with the platinum and palladium; without taking into consideration the fact the residue left behind by this digestion, is only filtered with infinite difficulty.

On the other hand, it is easy to effect the separation of platinum and palladium from the others, almost completely, if the original material is mixed in a Hessian crucible, with from $\frac{1}{2}$ to $\frac{1}{3}$ its weight of chloride of ammonium, heated until the latter is completely volatilized, allowed to glow gently until only the vapors of sesqui-chloride of iron show themselves, and then placed in a porcelain dish, and evaporated to a syrupy-consistency with from two to three times its weight of raw *commercial* nitric acid. By this treatment with chloride of ammonium, the metals present not belonging to the platinum group will have been partially converted to *lower chlorides*; rhodium, iridium and ruthenium will have been rendered insoluble, and the silica present as gangue, converted from a gelatinous mass, to a finely pulverent condition, in which state it will admit of speedy filtering.

The chlorine compounds, produced by the chloride of ammonium, give us, upon digestion with nitric acid, just enough hydrochloric acid to dissolve the platinum to bi-chloride, while the metallic copper and iron present, act in so far reducing upon the palladium (in solution in nitric acid) that it remains in solution not as bi-chloride (Pd Cl_2), but as the proto-chloride (Pd Cl), which latter is not precipitated with chloride of potassium. The mass is diluted with water, filtered, and the solution saturated with chloride of potassium, and the greater part of the platinum separated pure as K Cl , Pt Cl_2 , which is washed out, first with chloride of potassium, and later with absolute alcohol (the last washings must not be added to the solution). This precipitate weighed 62 grammes.

The filtrate is brought into a large flask (which can be made air-

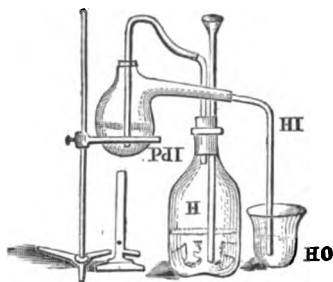
tight), which will not be more than half filled with it. Chlorine gas is led into this flask, and the same is from time to time shaken vigorously, until no further absorption of gas takes place, when all the palladium will have separated as a cinnabar-red precipitate of KCl , Pd Cl_2 (somewhat impure, however, from traces of platinum, iridium and rhodium). This precipitate weighed 157 grammes. The fluid from which these precipitates were obtained, is now evaporated, not quite to dryness, with hydrochloric acid, and upon addition of *just so much water as was necessary* to dissolve out the chloride of potassium and other soluble salts, (aiding the operation by rubbing with a pestle), there remained behind a dirty yellow-colored precipitate. This was separated by filtration, boiled with caustic soda, and a few drops of absolute alcohol, hydrochloric acid was added to dissolve the precipitate formed, and the liquid then saturated with chloride of potassium, the result was a precipitate of 13.5 grammes of chemically pure KCl , Pt Cl_2 . The mother-liquid contained only copper, and no platinum metals.

The purification of the cinnabar-red precipitate of palladium was accomplished as follows: It was dissolved in boiling water, whereby a portion of the chloride dissolves (with evolution of chlorine) to Pd Cl . It was then evaporated with 60 grammes of oxalic acid, and dissolved again in a solution of chloride of potassium, whereupon 42 grammes of K Cl Pt Cl_2 remained behind, which, upon testing, proved chemically pure. It was washed out as before.

The brown liquid was then somewhat concentrated upon the water-bath, and, upon cooling, there separated 19 grammes of bright green, well formed crystals of K Cl Pd Cl , (with some chloride of potassium) which, upon testing, likewise proved free from the other platinum metals.

The fluid poured off from these crystals was then neutralized carefully with caustic soda, and gave a very slight precipitate of copper and iron, which was filtered off. Upon adding iodide of potassium to the filtrate all the palladium separated as Pd I . To avoid adding an excess of the reagent, it is best to take, from time to time, a drop from the fluid with a capillary tube, and bring the same upon a watch-glass. As long as the precipitation is incomplete, the drop appears, upon a white background, *brown*; when complete, it is *colorless*; when the reagent is present in excess, it is *red*. This weighed 77 grammes, and was tested for its purity by reducing it to metallic palladium and then heating and dissolving in nitric acid;

when pure, it must dissolve completely. The whole mass was now reduced in a slow stream of hydrogen gas (whereby the iodine can be obtained again as hydriodic acid, by absorbing with water); at last the mass must be strongly heated to decompose slight traces of the sub-iodide of palladium (Pd_2I) which are formed.



The mother-liquid from which all this platinum and palladium has been obtained may contain some iridium and rhodium, it is, therefore, evaporated to dryness with a little iodide of potassium, whereby a mixture of the iodides of rhodium and iridium separates; this can either be dissolved in aqua regia, and the two metals separated, as will hereafter be described, by the bi-sulphite of soda, or it can be united with the portion from which these metals will be obtained.

Separation of Ruthenium and of Rhodium and Iridium.

The residue, from a kilogramme of the original material, which remained after treatment with chloride of ammonium and nitric acid, weighed 400 grammes. It was treated as follows, to get the metals in a form adapted to farther chemical treatment.

The method depends upon the behavior of chloride of zinc to zinc. If a piece of zinc be smelted, it rapidly covers itself with a stratum of oxide. If, to the smelted metal, a metal like iridium be added, the oxide stratum hinders the latter from coming into contact with the zinc, even though it be pushed beneath the surface; if, however, a few grains of chloride of ammonium be given to it, ammonia, hydrogen, and chloride of zinc will be formed, which last dissolves the oxide stratum to basic-chloride of zinc. The zinc below resembles mercury in lustre and movability. As soon as the chloride has dissolved as much of the oxide as is possible for it, the oxide stratum again forms, and is instantly removed again by the addition of more chloride of ammonium. The melted zinc (strewn with chloride of ammonium) also possesses, like mercury, the property of attacking other metals, if the affinity exists of forming with them alloys. By strewing chloride of ammonium upon the melted zinc, a quiet surging is kept up as the ammonia and hydrogen are given off. Many oxides and chlorides, among

which are those of the platinum metals, are, when they come into contact with this atmosphere of reducing gases, (and with the basic-chloride of zinc) instantly reduced and dissolved to alloys by the zinc. (We have here a means of separating, quantitatively, all metals which are not dissolved by zinc from those which are.) In making the solution, the zinc, in a porcelain dish, should be constantly rotated; the gangue remains in the basic-chloride. The regulus, immediately upon solidifying, should be taken from the capsule, out of the yet fluid basic-chloride, and washed off with acetic acid until all the basic-chloride is dissolved away. The gangue can be quantitatively determined by filtration and weighing. If the regulus is not immediately removed, the containing vessel will be broken, owing to the unequal expansion of the porcelain and the metal.

The best proportions for a quantitative separation are, to one part of the expected platinum metals, from 20 to 30 parts of zinc; for an ordinary separation, 7 parts of zinc is sufficient.

For the extraction of the residues remaining after our treatment with nitric acid, this method is admirably adapted; by fusing only once with zinc, for two or three hours, all the platinum metals are extracted. The operation is the following:—

From 3 to 3.5 kilogrammes of commercial zinc were fused in a two-litre Hessian crucible, chloride of ammonium, from time to time, strewn upon it, the 400 grammes of residue, previously heated to faint glowing with chloride of ammonium were added, and the temperature kept, for two or three hours, just above the fusing point of the alloy, by adding, whenever the mass threatened to solidify, some chloride of ammonium. The mass is divided into three strata after solidification has taken place.

The *outer* stratum, easily broken away by a blow from a hammer, contains *no* platinum metals. The *next* contains some particles of the zinc and platinum alloy imbedded in the basic-chloride of zinc; it is porous, and not very thick.

The *inner* stratum consists of a frequently beautiful crystalline regulus. To obtain the alloy from the middle stratum, it is only necessary to wash repeatedly with water; and the alloy gained is, of course, to be added to the regulus. To obtain this regulus as pure as possible, it was again fused with 500 grammes of zinc and some chloride of ammonia, then granulated in water, and the granules dissolved in fuming hydrochloric acid. The acid attacks the

regulus with the greatest energy, and the solution was completed in less than an hour. The chloride of zinc can be used for the next operation.

The platinum metals are found at the bottom of the vessel, in form of a finely divided black powder, and is impurified with zinc, and with traces of iron, copper, &c., from the latter. It cannot be purified with nitric acid, nor with aqua regia, for part of the platinum metals will thereby be dissolved, or, at best, so suspended in the fluid that filtration is impossible. If, however, the powder is treated with hydrochloric acid, singularly enough all the impurities are dissolved, not only zinc and iron, *but also lead and copper dissolve readily with the generation of hydrogen*. The explanation is readily found in electrical currents produced by the contact of the metals, the stream passing from the positive zinc, iron, &c., to the negative platinum metals; hydrogen being given on the latter and chlorine on the former, and uniting with them. The metals (rhodium, iridium, &c.), after thorough washing, weighed 65 grammes. This powder possesses the property, upon being gently heated, of exploding weakly, and, when highly heated, with violence, the explosion being accompanied with the evolution of light, thereby neither hydrogen nor chlorine, nor nitrogen, nor aqueous vapor are given off, and as these are the only elements which it is possible that the metallic powder could have taken up, it must be assumed these metals are, by our treatment, converted into an allotropic condition, and that, upon heating, they return, with more or less energy, to their original condition. The powder contains, mainly, rhodium and iridium, but there are traces present of platinum, palladium, lead, copper, iron, and zinc.

It was intimately mixed with about 3 or 4 times its weight of completely anhydrous chloride of barium, and a stream of chlorine gas lead over it at a tolerably high temperature. The operation is concluded when particles of sesqui-chloride of iron show themselves on the neck of the flasks containing the powder. It is carefully brushed away with filter paper. Some water was now added and the mass of the platinum metals dissolved with the evolution of heat. There remained behind 13·7 grammes of insoluble matter, which, upon reduction with hydrogen, alloying with zinc and treatment with hydrochloric acid, furnished 4·5 grammes of ruthenium. From the original 65 grammes of metal-powder, there was dissolved in three hours, and with the use of four ordinary burners, 57 gram-

mes of the platinum metals, there being consumed thereby 415 grammes of 85 per cent. black oxide of manganese. From this solution all the chloride of barium was removed by careful addition of sulphuric acid (see the precipitation of palladium). The platinum metals were now completely freed from all other metals by reduction with hydrogen (with 100 grammes of material this operation will require five or six days); the temperature being throughout the operation maintained at nearly 100°C ., by means of the constant water-bath. Platinum and palladium chiefly, separate first, then mainly rhodium, and the last portions consist almost entirely of iridium. It is best to break off the operation when the fluid has assumed a greenish-yellow color. The last portions of iridium (obtained by evaporating the solution to dryness, fusing with carbonate of soda, and treatment with aqua regia) were added to the portion, afterward to be again rendered workable by renewed treatment with chloride of barium. The operation of reduction is hastened by concentrating the fluid, in doing which, care must be taken to guard against explosion on account of the hydrogen. The separated metals were treated with aqua regia and the platinum and palladium thus dissolved, were separated from each other as above described. The traces of rhodium and iridium in the mother-liquid can be removed entirely by continued boiling with iodide of potassium, (whereby they precipitate as iodides,) dissolved in aqua regia, and added insoluble portion.

This insoluble and partly oxidized portion was now again reduced in hydrogen gas, treated, as before described, with chloride of barium, and after the removal of the barium, the last traces of platinum and palladium removed by boiling with caustic soda. Rhodium and iridium now alone remain to be separated.

The brown-red fluid was, for this purpose, evaporated with hydrochloric acid, and, after filtration, treated with bisulphite of soda, $\left(\begin{smallmatrix} \text{NaO} \\ \text{HO} \end{smallmatrix} \right) \{ \text{S}_2\text{O}_4 \}$ in *great excess*, and the whole allowed to remain quietly *in the cold* for several days. The double salt of rhodium ($\text{NaO} \cdot \text{SO}_2 \cdot \text{RhO} \cdot \text{SO}_2$) separates slowly, giving a lemon-yellow precipitate. The solution becomes lighter and lighter and finally almost colorless. The color of the precipitate changes with that of the fluid, becoming with it, lighter. This precipitate upon washing, contained the rhodium almost pure.

Upon heating the fluid gently, a yellow-white precipitate sepa-

rated, which consisted mainly of rhodium, but contained also some iridium. After filtering off this precipitate, the solution upon being concentrated to a small volume gave yet two precipitates:—

1st. A curdy, slowly separating, yellowish-white precipitate, nearly chemically pure iridium, containing but the faintest traces of rhodium.

2d. A heavy, crystalline powder, quickly separating, which was readily freed from the first by decantation, and weighed 16 grms. Upon testing, it gave all the reactions for iridium, but likewise some peculiar reactions not shown by the latter; it may possibly contain a new metal.

Exclusive of these 16 grms, the precipitate (the 1st.) weighed 99·5 grms. The mother-liquid was free from platinum metals. The complete separation of rhodium from iridium was accomplished by treating the yellow precipitates with concentrated sulphuric acid. They were brought in small portions into the acid, heated in a porcelain capsule, until all the sulphurous acid had escaped, and then left upon the sand-bath, until all the free sulphuric acid had been driven off; and the sulphate of soda formed. Upon boiling the mass of water, all the iridium dissolves as sulphate, with a chrome-green color, while the rhodium remains behind as a flesh-red double salt of soda and rhodium oxide. It (the latter) was washed by boiling in aqua regia and decanted with water. It is insoluble in water, hydrochloric or nitric acids and in aqua regia. The rhodium and iridium are now completely separated. The rhodium salt weighed 33·2 grms.

The following are the weights of the various precipitates obtained from one kilogramme of the original residue:

K Cl, Pt Cl ₂	= 117·5 grms.
Pd I	= 77·0 "
K Cl, Pd Cl.....	= 19·0 "
NaO SO ₃ , RhO. SO ₃	= 33·2 "
Ir ₂ O ₃	= 9·1 "
Ru. (+ Ir.).....	= 4·5 "

The first yellow precipitate, obtained in the cold, by the bisulphite of soda, gave by this treatment, the rhodium quite pure. The second and third precipitates containing much iridium gave a very fine rhodium, but still slightly impurified with iridium. The products, therefore obtained by this treatment with sulphuric acid (which betray their impurification from iridium by their somewhat brownish color) were collected for themselves. The rhodium sepa-

rated therefrom by glowing, treated again with chloride of barium, and the operation of separation repeated. The green solution containing only iridium was gradually heated over an ordinary burner, in a porcelain capsule, and afterward upon the sand-bath, to remove the excess of sulphuric acid; and finally the capsule and its contents were highly treated in a Hessian crucible. There is formed thereby sulphate of soda and sesquioxide of iridium. Upon boiling the mass with water, the last remained behind as a black, insoluble powder, which was readily washed by decantation. It weighed 9.1 grms.

In these operations, the new filtering apparatus and the continuous water-bath, with which I have furnished my laboratory, materially shortened the labor.

THE MELBOURNE TELESCOPE—REPORT OF COMMITTEE.

THE Committee were informed by Mr. Grubb at the close of last year that the telescope was ready for their final examination; but the bad weather which has prevailed in Ireland ever since precluded all trials of its optical power till February 17, when they met at Mr. Grubb's works in Rathmines Road.

1. The telescope was not finished at the time named in the contract; but the Committee have ascertained that the delay arose solely from unfavorable weather, which not only impeded the actual work of polishing, but for weeks together made it impossible to test the figure of the specula. They considered that it was far more important to send out a perfect instrument than to keep the exact time.

2. The Committee, after minutely and carefully studying the mechanical details of the equatorial, have come unanimously to the conclusion that it is a masterpiece of engineering. Its movements are surprisingly smooth and steady; it can be moved to any portion of the sky, even if it have to be reversed from one side of its pier to the other, in less than a minute by two operators, and with very little exertion.

The clock is smooth and equable in its action, it is very powerful, and quite equal to its work. Great change of rate, as from sidereal to lunar time, is effected by an ingenious piece of differential gearing; small changes are made by a cam adjustment; more-

over, it rings seconds, for the double object of comparing its rate with a chronometer, and to assist the observer in his observations.

3. The Committee are strongly impressed by the great convenience to the observer of the arrangements of the hour and polar-distance circles, the facility of controlling their adjustment, and the easy access to the eye-piece.

4. The stability of the tube was severely tested, both in respect of its general stiffness and its power of resisting torsion, such as might be produced by the weight of the small speculum when the telescope is off the meridian; and the results were highly satisfactory.

5. In large reflecting telescopes it is usual to make provision for keeping a given diameter of the great speculum always in a vertical plane. When they are equatorially mounted, this is done by rotating the tube in its cradle. Here the tube does not turn; but there is a special arrangement of hoop-suspension, by which, whatever diameter may be vertical, it is supported in a uniform and symmetrical manner. The system of triangular levers at the back of the great speculum is also contrived so as to prevent them from exerting any pressure which might distort it. This is a matter of the highest importance, and the attention of the Committee was specially directed to it. They examined it most carefully, putting the telescope in various positions of R.A and P. D. on each side of the meridian, both by day and night, and could not find *any sign of flexure or any distortion of the image in any of these changes.*

6. In order to test the optical power of the second speculum B (the first one A, had been tried and approved by a member of the Committee on October 12 last), the telescope was directed to the following objects:—In the daytime Venus and α Andromedæ; at night (which fortunately was clear and steady) Castor, the Great Nebula of Orion, ζ Orionis, γ Andromedæ, Uranus, 1 Messier, 37 Messier, 46 Messier, and 51 Messier, from which it will be seen that both the light-collecting and defining powers of the instrument were fairly tried. The powers used were 220 (the lowest which can take in the entire pencil), 350, and 450, all negatives. Of course one would not propose such an instrument for the measurement of close double stars, work for which telescopes such as those of Poulkova and Harvard are possibly better fitted; but the Committee found that the light even of large stars was collected into small, hard, and perfectly circular disks, free from rays; and though some diffused light* surrounded them, it was exactly concentric with the central

* The cause of this diffused light has since been discovered and removed.

disks. The 5th and 6th stars of the Trapezium of Orion were not only plainly seen, but were very bright; ζ Orionis was well shown, and the companion of γ Andromedæ was clearly divided with the powers of 350 and 450, and the different tints of the components were evident. Uranus was well seen, but was surrounded by such a multitude of very minute stars that, without access to the tables of his satellites, it was impossible to know whether any of them were seen.* 37 M. was broken into a heap of stars so large and brilliant that it quite lost the character of a cluster. The planetary Nebula in 46 M. brought out most strikingly the light-collecting power of this telescope; for it (which in most telescopes appears as a faint disk) was revealed as a ring, bright even on the dazzling ground of the surrounding stars, which here were as brilliant as the components of the Pleiades appear in ordinary instruments. With respect to the Nebulæ, it is needless to say more than that Lord Rosse considers its performance in bringing out the details of the Orion Nebula, 1 M. (the Crab), and 51 M. (the Great Spiral), quite satisfactory.

7. The Committee had no opportunity of testing the spectro-scope on stellar or nebular spectra; but they have tried it on solar and electric ones, and consider that it will be very effective, from the solidity of its structure, and its large dispersion combined with a small deviation.

8. The balance of the grant, which will probably be absorbed by the expense of packing the instrument for removal, was not sufficient to justify the Committee in ordering a photographic apparatus which should be worthy of the telescope; but some trials have been made with a "makeshift affair," which confirm them in their opinion that it is most important to turn to account the photographic power of this magnificent instrument, not only for the moon, but for the planets *and the sun*. On two or three occasions Castor and the moon were taken with this temporary apparatus; as to the star, its components impressed their images in good measurable disks in times varying from two to eight seconds; with respect to the moon, on February 1, when she was seven days old, and the air good, a remarkably hard and sharp picture, full of minute details,

* On the 19th of February, however, the Committee had the advantage of the presence of Mr. Lassell in the examination of Uranus among other objects with Speculum A, and, guided by his familiarity with that object, they were enabled to make out stars, the positions of which, with great probability, corresponded to the places of the two most distant, and one of the nearest satellites.

was obtained, which exhibits so strongly the great photographic power of the instrument, that they would regard it as a serious loss to science if this was not most fully brought into action. This is the more desirable because lunar and solar photography would utilize a considerable portion of time, during which the observing of nebulae is impossible. After full inquiry, the Committee find that the cost of the necessary apparatus for this work, including a micrometer for measuring distances and positions on the photographs (like that described in the *Phil. Trans.*, 1862, p. 373), could be provided for a sum not exceeding £400; and they earnestly hope that so valuable an addition may be made. They have been given to understand that the Melbourne Government have resolved on putting a roof over the instrument, but that they think it can be more economically constructed there than here. In this case, it occurs to the Committee that the second form of roof described in Dr. Robinson's letter might be preferable to the more complex one there recommended; and as it would be less costly, the difference would more than cover the expense of the photographic apparatus. In this hope they have directed Mr. Grubb to prepare a detailed plan of that apparatus and of the second form of roof. The Committee conclude by stating that they have no hesitation in declaring that the instrument is perfectly fit for the work for which it was destined. They therefore consider that Mr. Grubb has fulfilled his contract, and have directed him to lose no time in preparing the necessary cases and packing it for Melbourne. They have also instructed him to insure it against the risk of fire during its stay.

The Committee feel bound to say that Mr. Grubb has put a most liberal construction on the terms of his contract; and after their minute examination of the excellence of the telescope, and the amount and perfection of the machinery connected with it and its manufacture, they are convinced that Mr. Grubb has been more influenced by the desire of producing a perfect instrument than by any prospect of pecuniary advantage, and can scarcely realize the possibility of giving so much for the sum named in the contract, especially when it is considered that special works had to be erected for the purpose of constructing the telescope.

Feb. 19, 1868.

ROSSE,
T. R. ROBINSON, D.D.
WARREN DE LA RUE.

P. S. March 7th, 1868.—I would strongly recommend that the photographic apparatus should be fitted to the telescope before it leaves Ireland.

WARREN DE LA RUE.

ON A NEW SPECTROSCOPE, WITH CONTRIBUTIONS TO THE SPECTRAL ANALYSIS OF THE STARS.

BY PROF. J. C. F. ZÖLLNER.

From the Reports of the Royal Saxon Academy of Sciences, Leipsic, Feb. 6, 1869. Translated from No. 1772 (Sept. 15, 1869) of the *Astronomische Nachrichten*, by Prof. Alfred M. Mayer, Ph. D.

THE spectral analysis of the stars, apart from the information which it gives concerning the physical constitution of heavenly bodies, has of late attracted considerable attention in another and not less interesting direction. There is a prospect of our being able by means of it to prove, and even to measure, the influence which the component of the relative motion of the earth and of the observed star, acting along the line joining them, exerts upon the position of the spectral lines.

It is clear that the influence which two separated bodies exert upon one another, by periodical impulses of finite velocity of propagation, must be modified by a constant change in the distance of the two bodies. Doppler has the merit of having first perceived the necessity of such an influence, in 1841, although his conclusions concerning the colors of the stars must be considered incorrect, because he neglected to consider the invisible portions of the spectrum.

Numerous experiments, by Ballot, Mach and others, have proved with reference to *sound* that the above influence is in accordance with the demands of theory.

With reference to *light*, however, it has not been possible hitherto to detect by observation such magnitudes of this influence as could be clearly demonstrated; because even the cosmical motions which are the most rapid at our command, are very slow when compared with the velocity of light.

The great improvements made in the optical instruments since the discovery of the spectral analysis, give us the hope of showing the above influence in the spectra of the stars. According to theory this influence must show itself in the displacement of the spectral lines. The amount of this displacement would be one-tenth of the distance between the two sodium lines, for the mean velocity of the earth, of 4 German miles a second.

This amount, which can be very easily calculated from the velocity of light and the duration of the undulations of the rays produc-

ing the soda lines, has very recently been again computed by J. C. Maxwell, in accordance with the former calculations of F. Eisenlohr and others.

The amount of the displacement seemed to Maxwell to be so small, that he closes his remarks with reference to the present form of the spectroscope and to the method of determining the position of the lines, as follows: "It cannot be determined by spectroscopic observations with our present instruments and it need not be considered in the discussion of our observations."

Huggins has, nevertheless, in his latest treatise, containing the experiments of Maxwell, attempted to solve the problem by the use of a spectroscope consisting of not less than 5 prisms, of which 2 were flint glass *Amici's*, and 3 crown glass prisms.

The loss of light, caused by the large number of prisms, permitted him only to observe the brightest stars. He confines his communications to a statement of the results of his observations on Sirius, and thinks that he has found a slight displacement of the line *F*, as compared with the hydrogen line produced by a Geissler's tube.

The direction and amount of the displacement would indicate an increase of the distance between the earth and Sirius with a velocity of 41.1 English miles per second.

If the components of the motion of the earth, which amounted at the time of observation to 12 English miles, are eliminated, the velocity with which Sirius and the sun separate from one another would equal 29.4 English or about 6.4 German miles.

Huggins himself considers this result as very uncertain, partially on account of the above mentioned great loss of light, and partially on account of the difficulty of comparing the coincidences of the *bright* lines from terrestrial sources of light, with the *dark* ones in the sidereal spectra. Sometimes the latter also have a different appearance, *e. g.* they may be blurred and of different width, as is the case in the line *F* of the spectrum of Sirius.

I think that I have overcome the most material of these difficulties which have hitherto impeded the solution of the problem, by means of a spectroscope of new construction, the first specimen of which I have the honor of placing before the Royal Society.

The construction is as follows: The line of light produced by a slit or by a cylindrical lens is in the focus of a lens, which makes the rays parallel as in other spectroscopes. Then the rays pass through two

Amici's systems of prisms, *à vision directe*, which I have received from Mr. Merz, Munich.

These are so placed side by side that each gives passage to one-half of the rays coming from the object-glass of the collimator, but so that the refracting edges lie on opposite sides. By this means all the rays are separated into two spectra of opposite direction. The object-glass of the telescope, which unites the rays again to one image, is cut perpendicular to the horizontal refracting edges of the prisms, as in the heliometer, so that each half can be micrometrically moved either parallel or perpendicular to the line of bisection. By this means we are enabled not only to make the lines of both spectra coincide, but to place the two spectra side by side instead of superposing them (so that one is placed beside the other like a *nonius*) and also to partially superpose them. By this construction the sensitiveness of the double image is not only turned to account for determining any change of position in the spectral lines, *but every such change is also doubled* because the influence acts in opposite direction in the two spectra.

The principle of the *reversion of the spectra* which forms the basis of the instrument and which determines me to give it the name of

Reversion-Spectroscope

may also be applied without the use of the *Amici* system of prisms. It is only necessary to reverse a portion of the rays passing through a common prism by means of reflection by mirror or prism, and then to observe the whole pencil of rays with the bisected object-glass of a telescope, as above. The principle also renders the introduction of artificial sources of light for the examination of slight changes of refrangibility entirely dispensable, and allows their detection and determination by the change of position of perfectly similar objects.

The measurements made on the dark (*D*) lines of the sun's spectrum, as well as on the light soda lines of a candle-flame impregnated with common salt, which are given here to enable you to judge of the power of the instrument, justify the hope that we may be able, by means of this spectroscope, not only to observe the influence of the earth's motion, but also to determine it quantitatively, with such precision as is desirable for the preliminary control of theoretical conclusions.

The figures given refer to parts of the micrometer screw, and show the separation of the two soda lines.

Soda Flame.	Sun.
49.5	49.5
50.5	51.5
53.0	48.1
49.5	48.9
Mean 50.6 $\pm$ 0.6	Mean 49.6 $\pm$ 0.5

In the following series of observations, the reversion-spectroscope was provided not only with another micrometer screw with a somewhat coarser thread, but also with two other systems of prisms, whose dispersion in the region of the soda line, was 1.77 times greater than that of the prisms used above. The achromatic object-glass of the collimator, and of the telescope, were also replaced by non-achromatic glasses, by which the sharpness of the images was not impaired, and the clearness and strength of the light were increased.

SUN.

Parts of the Screw.	Deviations from the Mean.
67.1	- 0.8
69.4	+ 1.5
68.4	+ 0.5
67.9	0.0
66.6	- 1.3
66.1	- 1.8
68.2	+ 0.3
68.0	+ 0.1
69.6	+ 1.7
Mean 67.9 $\pm$ 0.3	

The distance between the two *D* lines is, therefore, exactly determined, with the exception of a probable error of $\frac{1}{2}$ Å. According to the above, however, a change of the distance between the source of light and the spectroscope, with a velocity of 4 miles a second, would produce a mutual displacement of the lines of both spectra, equal to $\frac{1}{4}$ of that distance, a magnitude about 40 times greater than the probable error in the mean of 9 readings.

If, in the observation of the spectra of stars, a sufficient amount of light can be employed, we can definitely decide, by the above means, whether or not the expected displacement of the spectral lines occurs. As regards the amount of light necessary, I may observe, that I use a non-achromatic lens of 1 Paris foot diameter and 6 feet focus. The rays from this lens are caught by a concave meniscus of flint-glass, a few inches before the point where they meet, and are thus led into the slit of the spectroscope, as free as possible from spherical and chromatic aberration. I think it necessary to call especial attention to the fact, that it is immaterial whether the image is achromatic or not when a slit is used, especially if only parts of the spectrum are observed. On this account, the above construction is preferable to one with powerful achromatic lenses, as being less expensive. It is, however, inapplicable when, as is the case with double stars, the bodies observed must be separated as sharply as possible.

Finally, I may be allowed to make a few remarks on problems and methods concerning the spectral observations of the sun, in which I am at present engaged.

The velocity of rotation of the sun is such that a point of its equator moves with a rapidity of about 0.25 German miles per second. If, now, we obtain by means of a heliometer, or in some other way, a double image of the sun, and two points of the equatorial edge are made to touch, then parts of the sun's surface at the point of contact will approach us with the given velocity, while others will recede from us with the same velocity. This will produce a difference of velocity of the parts in contact in the line of vision amounting to about half a German mile. According to what has been said above, such a velocity would make a change in the position of the soda lines amounting to the 80th part of the distance between them. In order, therefore, to detect and measure this change by means of a sufficient number of prisms, it is only necessary to bring the centre-line of the slit of the spectroscope into the line of the centres of the two images of the sun, and we shall see the two spectra of the edges in contact, side by side, in the field of vision of the spectroscope, and thus observe the displacement in question under the most favorable circumstances. In this manner the position of the sun's equator, and, if the displacement can be measured, the rotary velocity of different heliographic latitudes could be determined, which

would be of the highest interest, with respect to the latest opinions on the subject.

Even disregarding the quantitative determination of the phenomenon in question, the mere qualitative proof would afford a simple means of *separating all lines produced in the sun's spectrum by the absorption of the earth's atmosphere from those which owe their origin to the solar atmosphere*, since the displacement can obviously extend only to the latter.

Another subject for spectroscopic research are the protuberances of the sun. Lockyer and Janssen were the first who succeeded in observing the spectrum of the protuberances (which consists of three bright lines) independently of a total eclipse.

At present, exertions are made to devise methods for observing not only these lines, but also the whole shape of the protuberances together.

The length of the bright lines corresponds to the size of the protuberance in the direction of the slit. If, therefore, the slit is brought successively in different positions, so that it cuts the protuberance in many directions, we can construct the shape of the latter, as, indeed, Lockyer has already done. Based upon this principle, Janssen proposes to construct a rotating spectroscope, so that the whole shape of the protuberance can be seen at one glance when the spectroscope is revolved with sufficient rapidity.

Apart from the mechanical difficulties of such a rotating spectroscope, in which one of the three bright lines must lie exactly in the axis of rotation, the end in view can be more easily and perfectly attained by making the slit oscillate perpendicularly to its direction. In this way we could observe the same protuberance simultaneously in three differently colored images, corresponding to the three different lines of its spectrum.

According to these methods, with a movable slit, the brightness would be diminished in proportion to the distance traveled over by the slit. Especially in the rotating spectroscope, the brightness of the protuberance itself would decrease from the centre of rotation to the edge, and thus prevent the observation of the natural brightness of its parts.

For this reason, I intend to employ another very simple arrangement. I have convinced myself of its practicability by the experiments on terrestrial sources of light described below. The principles upon which it is based are as follows:—

1. The apparent brightness (*lustre, claritas visa*) of a protuberance-band is independent of the opening of the slit, provided that it retains an appreciable breadth on the retina.

2. The brightness of the superposed spectrum increases in proportion to the width of the slit.

3. In oscillating or rotating slits the brightness of the superposed spectrum remains unchanged, while that of the image of the protuberance produced by the permanence of the light, decreases according to another law, depending upon the number and duration of the impressions on the retina, and on the refrangibility of the observed band of the protuberance.

If, for simplicity, we suppose that the whole surface over which the slit travels in its rotation or oscillation is filled with the protuberance, and that the intensity of the produced secondary image is in inverse ratio to that surface (corresponding to a uniform diffusion of the light over that surface through a *stationary* slit), then the relation of the intensity of the background to that of the protuberance would remain the same, whether we

First, decrease the brightness of the protuberance by means of *oscillation* of the slit, and thereby leave the brightness of the superposed spectrum or background (according to 2) unchanged, or

Secondly, open the stationary slit so widely that the opening extends over the space traveled over by the oscillation of the slit in the first case. By this means (according to 1), the apparent brightness of the protuberance remains unchanged, while that of the background is increased in the same ratio in which it was diminished before with a constant background.

If these suppositions are correct, the end in view can be much more easily attained in the second way, if we take care not to admit the intense light of the body of the sun into the slit.

It is only necessary to open the slit so far that the protuberance, or a portion of it, appears in the opening. By polarizing or absorbing media, placed before the eye-piece, the light in the whole field of view, can be so diminished that the proper relation of intensity between the protuberance and the superposed spectrum may be obtained.

Led by these considerations, I have tried to realize the circumstances under which the protuberances are visible, with the aid of terrestrial sources of light, in order to test both methods, and convince myself of their practicability. The following observation is necessary to the better understanding of these experiments.

The reason why the protuberances are not visible on diaphragming off the intense image of the sun is, that strongly illuminated portions of our atmosphere lie above and cover the image of the protuberances. In a total eclipse of the sun this illumination is so considerably weakened that the intensely luminous protuberances stand out from the illuminated portions of the corona. How much the diffused light of our atmosphere is weakened is seen in the fact that its mean strength is about equal to that of the full moon. According to my photometric measurements, this illumination is 618,000 times less than that produced by the sun. Therefore, the selective absorption of colored media must be in the same relation to the homogeneous light of the protuberances, if, as has been attempted, we try to make the protuberances visible in this way without dispersion.

On the other hand, the possibility of accomplishing our object by means of the prism, by the dispersion of the superposed atmospheric light, rests mainly upon the fact that this light is composed of rays of all degrees of refrangibility, while that of the protuberances consists only of 3 kinds of rays.

I have artificially produced the superposition of a non-homogeneous mass of light on a body of well-defined outline, and shining with a homogeneous light, in the following way:—

The wick of an alcohol flame was impregnated with common salt and chloride of lithium. At a distance of 18 feet from this flame, plate of glass was placed at an angle of 45° to the line of observation, so that the reflected image of a petroleum flame covered weak alcohol flame, and rendered it entirely invisible by its greater intensity. About 1 foot from the mirror was a small lens, of 6-inch focus, which threw a small image of the alcohol flame into the slit of the spectroscope. The latter was fastened, at one end, to a spring 10 inches long, so that, by disturbing its equilibrium, oscillations of sufficient amplitude would be produced for the space of about 5 minutes.

Then the width of the slit was so far diminished that the double line, *D*, and the lithia line (although proportionally weaker) appeared sharply defined in the field, when the apparatus was at rest. As soon as the oscillations commenced, these lines were converted into sharp images of the alcohol flame, and the two soda images overlapped about one-half. These three images were less bright than the three light lines, and, consequently, their contrast with

the diffusely illuminated background of the spectrum was also proportionally less marked than that of the lines when the slit was stationary.

As soon as I tried the second of the above methods by opening the slit (keeping the apparatus at rest) so far that the image of the alcohol flame was just enclosed by the rectangular opening of the slit, I was astonished at the far greater beauty and clearness of the contrast of the images with the background.

It seems, therefore, that there is a greater loss of light when an oscillating slit is used than in the latter method.

As will be readily seen, there is no principle which will prevent the application of this method to the observation of the protuberances (the author has not yet had the opportunity of doing so) With the given relation of intensity between the homogeneous light of the protuberances and that of the superposed atmosphere, the practical success depends merely on the question whether a sufficiently strong dispersion can be effected. If the intensity and clearness of the protuberance lines observed by me at the Berlin Observatory on the 24th of December, 1868, warrant the conclusion that the light of the protuberances is relatively of considerable intensity, then the *four* excellent systems of prisms at present in my possession will probably enable me to solve the problem of the visibility of the protuberances in a satisfactory manner, according to the method described.

APPENDIX.

Being informed that Mr. Lockyer has succeeded in observing the protuberances by means of a spectroscope with 7 prisms, I will make the following additional statements:—

The spectroscope, which was made according to my direction, by Tauber, of Leipsic, contains but *one* prism, *à vision directe*, by *Merz*. It was attached to the 6-foot Fraunhofer's Refractor, of this Observatory. The height of the slit was 6' 20'', and the opening varied according to the height and size of the observed protuberance. It is most advantageous to make the length of the slit a tangent to the edge of the sun. In this way we see more of the edge at once, and we are also enabled to determine the angle of position of the protuberance more exactly, since the sun's first entrance in the slit produces a flash of a narrow tape-like spectrum in the middle of the field of view. The point where this flash appears can be easily

brought to the place of the protuberance by turning the spectroscope around the axis of its length, and the slit then forms a tangent to that spot of the sun's edge which is occupied by the protuberance. The position of the spectroscope can then be read off on a graduated circle, and thus gives the angle of position of the protuberance.

We may avail ourselves of two different methods of bringing the different points of the sun's edge into the slit. According to one, the object glass of the refractor is so fastened in a ring that its optical axis is inclined about $15'$ to the longitudinal axis of the tube. If this ring is turned, by means of a screw on the tube, the optical axis of the object-glass will describe a cone of about $30'$ aperture, so that different portions of the sun's edge are brought successively into the focus before the centre of the slit. Of course, the position of the latter must be varied in a corresponding manner by turning the spectroscope.

According to the other method, which has the advantage of an unchanged position of the slit, the rays are passed through a so-called reversion-prism before they unite to form an image. If this prism is turned about the axis of the instrument, the image of the sun will also rotate about its centre, and thus allow different portions of its edge to fall successively upon the slit. The angle of position is then determined by the position of the prism of reversion.

The size of the image of the sun in the refractor, or, in other words, the focal distance of the object-glass used, plays a very important part in the whole method. From the theory of the method stated above, it follows that with the same spectroscope the contrast between the protuberance and the background depends solely on the opening of the slit. Since, with a constant aperture, the smaller the sun's image, the greater the portion of the protuberance seen at once, it follows that we must not seek to magnify the protuberance to be observed by means of the sun's image, *i.e.*, by a large focal distance of the object-glass of the refractor, but by the arrangement of the lenses of the spectroscope. It can easily be accomplished by using a collimator with a small focal distance in comparison to that of the telescope. Suppose we have a refractor of 10 feet focal distance, to be used in conjunction with a spectroscope in which the focal distances of both object-glasses are equal. If it is now necessary to open the slit until the aperture is one millimetre, in order to observe a protuberance of a certain size, this

opening could be reduced to $\frac{1}{10}$ millimetre, if the image of the sun were only $\frac{1}{10}$ as large, which would still leave the whole of the protuberance visible while giving it a ten-fold greater contrast with the background of the spectrum. Now, in order to magnify the protuberance in the *field of view*, so as to make up for what it lost by reducing the size of the sun's image, it is only necessary to make the focal distance of the collimator 10 times shorter than that of the spectroscope. Using the same illustration, we would obtain an effect 10 times better with *the same optical magnifying power and the same system of prisms* if instead of a 10-foot refractor, a telescope of only 1 foot focal distance were used, making the focal distance of the collimator about 2 inches and that of the observing telescope 20 inches. The excellence of the images is very little influenced by the system of lenses, since the errors from chromatic observation entirely disappear on account of the homogeneous nature of the light of the protuberance. For this reason, as I have convinced myself by numerous experiments, non-achromatic lenses can be used for such combinations. The extraordinarily small space into which the instruments for the observation of the sun's protuberances can be brought by this means, allows the employment of finely-regulated clock-work, and thus opens the prospect of producing *an artificial total eclipse of the sun of any desired duration for the simultaneous observation of all the protuberances on the sun's edge.*

Coloring of Small Metallic Objects.—M. Pusher makes a solution of four ounces of hyposulphite of soda in a pint and a half of water, and adds a solution of one ounce of acetate of lead in the same quantity of water. Articles to be colored are placed in the mixture, which is then gradually heated to a boiling point. The effect of this solution is to give iron the effect of blue steel, zinc becomes bronze, and copper or brass becomes successively yellowish red, scarlet, deep blue, bluish white, and finally white with a tinge of rose. This solution has no effect on lead or tin. By replacing the acetate of lead in the solution by sulphate of copper, brass becomes of a fine rosy tint, then green, and finally, of an iridescent brown color. Zinc does not color in this solution, it throws down a precipitate of brown sulphuret of copper, but if boiled in a solution containing both lead and copper, it becomes covered with a black crust, which may be improved by a thin coating of wax. If the lead solution be thickened with a little gum tragacanth, and patterns be traced with it on brass, which is afterwards heated to 212° , and then plunged into solution No. 1 a good effect is produced.

SPECTROSCOPIC NOTES.

By PROF. C. A. YOUNG, of Dartmouth College.

*Observations on the Solar Prominences.**Sept. 16th, 1869.*—2 to 3.30 P. M. Clear and calm.

Protuberances were observed on the sun's limb as follows :

No.	Position.	Solar Latitude.	Height.	Remarks.
1	0°	+ 64°	20''	
2	70	+ 46	35	
3	132	— 16	15	Small, but very bright.
4	160	— 44	20	Small and faint.
5	175	— 59	60	Faint.
5	238	— 52	20	
7	337	+ 41	45	Pretty bright.

Sept. 24th.—1.50 to 4 P. M. Flying clouds and a fresh breeze.

Protuberances noted as follows :

No.	Position.	Latitude.	Height.	Remarks.
1	65°	+ 52°	15''	Bright.
2	90	+ 27	30	"
3	102	+ 15	35	Faint.
4	150	— 33	65	Diffuse and nebulous; rather faint.
5	165	— 48	55	Of medium brightness.
6	240	— 56	35	45'' long. Nebulous and diffuse.
7	250	— 46	15	Pyramidal and well defined.
8	285	— 12	20	Bright. Mushroom formed.
9	342° to 355°	+ 45° to 58°	45'' to 70''	Large and bright, 3 distinct peaks.

On the eastern limb (position-angle 97°) there was a spot within 10'' of the edge of the disc. There was no prominence over or very near it, but if anything the chromosphere was somewhat shallower just at that point.

At 2.50 P. M. a distortion of the F line was noticed at a point on the sun's disc about 30'' from the edge, and some 20'' east of an extensive cluster of spots near the eastern limb.

At one time there was a little bulb attached by a short ligament to the upper (more refrangible) edge of the line, and extending distinctly beyond the fine iron line which lies just above it. Some 10'' below the bulb there was a small lump on its other edge, and between them it was irregularly thickened. Fig. 12 represents the appearance of F during the phenomenon.

Fig. 12.



The bulb lasted only about *one* minute, but more or less deformation of the line was evident for about *ten* minutes, and was observed also on the C line though not so clearly. It could not be detected in D₃ (1017.5).

The observations this day were somewhat interfered with by the clouds, and still more by the wind, which at times made the instrument so unsteady as to render the determination of the position-angles uncertain, possibly to the extent of 10° in the worst cases.

Sept. 28th.—5 to 5.30 P. M.

No.	Position.	Latitude.	Height.	Remarks.
1	60°	+ 57°	20''	Fig. 10, Plate I. Very bright.
2	163	— 46	45	
3	172	— 55	35	
4	215	— 62	30	Faint and diffuse.
5	345	+ 48	120	

No. 3 was intensely bright and of very curious form, much like the gable end of a roof. I have endeavored to represent it in Fig. 10, Plate I. It was probably formed by two pillars of flame (?) standing at opposite angles of inclination one behind the other, in this respect imitating the structure of the "antelope horn" protuberance, which was so conspicuous on the eastern limb of the sun during the late eclipse.

Sept. 30th.—3.45 to 5 P. M. Air hazy.

No.	Position.	Latitude.	Height.	Remarks.
1	65°	+ 53°	35''	A little horn. inclined 45° towards the south.
2	85	+ 33	30	
3	92	+ 26	20	
4	105	+ 13	30	Brilliant, Fig. 13.
5	175	— 57	30	
6	230	— 68	45	
7	247	— 51	35	
8	267	— 31	60	Bright, double, Fig. 14.



Fig. 13, No. 6, Sept. 28th.

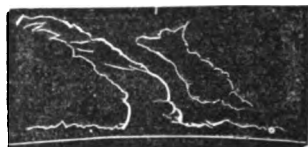


Fig. 14, No. 8, Sept. 28th.

Oct. 1st.—2 to 4.15 P. M. Flying clouds troublesome.

No.	Position.	Latitude.	Height.	Remarks.
1	75°	+ 43°	65''	Bright at base.
2	150	— 32	35	Brilliant.
3	165	— 47	60	Faint.
4	232	— 66	45	
5	245	— 53	60	Clouds interfered.
6	270	— 28	30	Faint, mushroom shaped, Fig. 15.
7	335	+ 37	55	Bright, Fig. 16.



Fig. 15, No. 6, Oct. 1st.

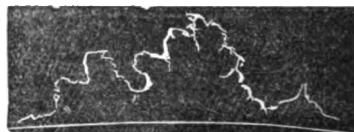


Fig. 16, No. 7, Oct. 1st.

Oct. 2d—2 to 3.15. Too windy for satisfactory work.

No.	Position.	Latitude.	Height	Remarks.
1	70° to 80°	+ 38° to 48°	30'' to 35''	Extensive range, bright at points.
2	118°		35	Faint.
3	150	— 32	.....	A detached cloud 25'' above limb, 20'' diameter, Fig. 17.
4	237 to 242	— 56 to 61	45	Length 90''.
5	276	— 22	35 to 60	Double headed.
6	340	+ 42	75	A vertical pillar.



Fig. 17. No. 3, Oct. 2d.

Of these, Nos. 1, 3 and 7 are evidently the same with Nos. 1, 2 and 6 of the preceding day. It is doubtful whether No. 4 can be identified with either 4 or 5 of Oct. 1st.

Oct. 7th.—1.30 to 4.15 P. M. Everything favorable to observation.

No.	Position.	Latitude.	Height.	Remarks.
1	70° to 78°	+ 40° to 48°	120''	Enormous. Fig. 5, Plate I.
2	90 to 95	+ 23 to 28	45	Faint.
3	100	+ 18	25	Very small and faint.
4	125	— 7	75	Magnificent, Pl. I, Figs. 1, 2, 3 & 4.
5	145 to 150	—27 and 32	30 and 85	Two small curved horns.
6	183	— 65	20	Small but brilliant peak.
7	264	— 34	15	Surrounded by nebulosity.
8	280	— 18	60	Pretty bright. Hazy.
9	316	+ 18	25	Long low mass of cumulo-stratus.
10	332	+ 34	.....	Small horizontal cloud 15'' above the limb, 15'' by 5''.
11	355	+ 57	45	Brilliant and of curious form. Plate I, Fig 9.

Several of the prominences observed this day were very remarkable. No 1 was of enormous magnitude and singular form, which I have endeavored to represent in Plate I., Fig. 5, (taken at 2.45.) The structure of the large faint mass was rather cumulus except upon the following edge, which was more filamentary and cirrus. The smaller but much more brilliant peak was very like the flame of a bonfire in its general appearance. No. 11, represented in Fig. 9, Plate I., was noticeable for its brilliance and the verticality of its component filaments. This was in striking contrast with the structure of No. 4 in which the elementary flocculi were nearly horizontal. This latter protuberance, taking everything into account, its magnitude, brightness, the rapidity of its changes, and their suggestive character, was the most remarkable I have yet observed, with perhaps one exception. Fig. 1, Plate I., delineates its appearance at 2.20 P. M. Fifteen minutes later, accidentally returning to it, I was astonished to find it as represented in Fig. 2, and while I was sketching it, unless my eyes greatly deceived me, the pointed extremity *flickered back and forth to the extent of 5'' (2,250 miles) in as many seconds of time.* The motion was both lateral and longitudinal like a tongue of flame, not apparently a mere pulsation of light. I record this with some misgiving, knowing how easily the eye may be cheated by the imagination, but at the time the impression was one of certainty. Fig. 3 shows the

appearance of the prominence at 2.55. The little projections from the chromosphere are nearly gone, and the cloud, which floated above, has united with the main body. Fig. 4 was taken at 3.30; the prominence then was certainly not more than one-fourth as brilliant as when first observed. (On the next day, as will be seen, it was hardly visible.) At 3 it distinctly reversed the two magnesium lines b_1 and b_2 for about 10" in its stem. It also showed a bright line clear and unmistakable at K 2581.5, as determined by direct reference to Kirchhoff's map. It was *not* the upper magnesium line, which is situated at 2567, nor could I make out any bright line there.

This observation has led me to doubt whether the line given in my eclipse report at K 2602 is rightly placed. A correction of one revolution of the micrometer screw, by means of which its position was referred to 2796, would give 2582.5 for its true position; and I might easily have committed such an error in the excitement and haste of the moment.

At 1.40 a curious phenomenon was seen on the body of the sun at a point about 35" distant from the limb (position-angle 266°). It was seen on both the C and F lines, but best on the former. The line was slightly bulged for about 8" in length, and both above and below the bulge there was a little blaze of light extending some 5" or 10" each side of the dark line, *but without reversing it*. The appearance is just what is seen on bisecting a bright star with a wire not quite thick enough to cover it. Plate I., Fig. 11, (the lower portion) represents the phenomenon.

Oct. 8th.—1.50 to 4 P. M. Weather very fine for observation.

No.	Position.	Latitude.	Height.	Remarks.
1	70°	+ 48	135"	Enormous, Fig. 6, Plate I.
2	95	+ 23	25 to 35	Three summits, bright.
3	125	— 7	45	Faint flocculi, detached from limb.
4	170	— 52	30	Faint.
5	184	— 66	15	
6	237	— 61	30	
7	255	— 43	35	Very bright and curious. Figs. 7 and 8, Plate I.
8	290	— 8	15	Bright though small.
9	340	+ 42	25	Faint.

A day's interval had entirely altered the appearance of No. 1, as is at once evident on comparing Figs. 5 and 6, Plate I. (The lat-

ter was taken at 3.30 P.M.) No. 2 had become much more conspicuous than on the day preceding. No. 3 would very likely have escaped notice had not attention been naturally directed to the point where so magnificent phenomena were exhibited only twenty-four hours previously. Nothing remained but mere debris, a few faint filaments of nebulosity floating above the limb. No. 5 is undoubtedly identical with No. 6 of the 7th, and hardly altered. No 7 was an active little affair, which varied in form with great energy and rapidity, as will be evident on comparing Figs. 7 and 8, Plate I.; the first representing its appearance at 2.30 and the second at 4 P.M.

For about ten minutes (2.25 to 2.35) the C line in the spectrum of a brilliant floccule on the upper right hand extremity in Fig. 7, presented the appearance depicted in the upper part of Fig. 11, Plate I. For about 7'' the line was double and this when the slit was closed to the utmost, showing that the doubling originated not in a mere juxtaposition of two masses of moving gas, but in their superposition, one in front of the other; one of them receding from us at the rate of some 60 miles per second.

Oct. 11th.—3.30 to 5 P.M. Clear but too windy for sketching.

No.	Position.	Latitude.	Height.	Remarks.
1	70° to 85°	+ 32° to 47°	180''	Enormous, diffuse, amorphous, in several masses, nowhere very bright.
2	102	+ 15	35	Faint.
3	125	— 8	.....	Small faint cloud 20'' above limb.
4	138	— 21	30	Pretty bright.
5	160	— 43	45	Bright.
6	170	— 53	30	Little horn, faint.
7	240	— 51	60	Cirrus and flocculent, fairly bright.
8	260	— 37	35	Bright.
9	315 to 330	+ 28 to 43	50	A long mass of cumulus form.
10	350	+ 63	35	Bright, a low flat arch, Fig. 18.

I suppose, though it hardly seems possible, considering that since the 7th the sun had rotated more than 45°, that No. 1 of this day must be identical with No. 1 of the 7th and 8th. No spot appears at or near its base. No. 3 seems also to be the remainder of the great prominence of the 7th, but this is very doubtful.



Fig. 18, No. 10, Oct. 11th.

Oct. 22d.—2 to 4 P. M. Rather windy.

No.	Position.	Latitude.	Height.	Remarks.
1	65°	+ 52°	45''	Faint.
2	120	— 3	25	Small and faint.
3	155	— 38	70	Bright. A nearly straight vertical pillar.
4	165	— 48	85	2 horizontal clouds, cirro stratus.
5	240	— 57	45	Faint.
6	280 to 290	— 12	15	Long and low.
7	335	+ 28	15	A little peak.
8	350	+ 53	20	Small but bright.

Nov. 4th.—3.30 to 5 P. M. Calm but very hazy.

No.	Position.	Latitude.	Height.	Remarks.
1	45°	+ 70°	35''	A little horn slightly curved.
2	52	+ 68	45	Sabre-formed, Cirrus and filmy.
3	93	+ 22	.....	Small cloud at an elevation of 50'', 10'' by 30''.
4	115	0	25	Small and faint.
5	127	— 12	20	Very bright. Exactly over a small spot within 15'' of the limb.
6	152	— 37	70	Diffuse and structureless.
7	170 ± 5	— 55 ± 5	50	Faint.
8	252	— 43	45	Horn-shaped, rather faint.
9	260	— 85	20	A little horn rising from a hollow in the chromosphere, near large spot, Fig. 19.
10	310	+ 15	40	Faint and nebulous.
11	330	+ 35	55	Mushroom-shaped.
12	345	+ 50	65	Peculiar, Fig. 20.



Fig. 19, No. 9, Nov. 4th.

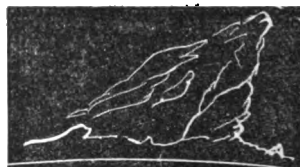


Fig. 20, No. 12, Nov. 4th.

From the observations above detailed it is evident that the spots and prominences obey nearly the same laws in respect to their dis-

tribution on the solar surface; but the prominences, which are far more numerous than the spots, approach nearer to the poles, and are more frequently found on the equator. I have never yet been able to watch a spot in its passage around the limb, so that I could observe its effect on the chromosphere, but my present impression is that certain depressions, from time to time observed in the chromosphere, (see Fig. 19,) are due to spots directly under them. In only one case (No. 5, Nov. 4th) have I found a prominence very near a spot, and then only a small one. The spot referred to in connection with No. 9, Nov. 4th, was about 25'' from the limb. Neither did spots make their appearance at or near the base of the great protuberances observed Oct. 7th. If they had they must have been seen on Oct. 11th. Whether the prominences are connected with the faculæ is a different question, and more likely, I think, to receive an affirmative answer. Their structure, as seen in my instrument, is almost invariably that of the most gauzy cirrus, composed of filaments and floccules so delicate that only an accomplished artist could hope to delineate them, and of which my figures hardly give an idea. Occasionally, however, they assume the apparent solidity of a cumulus or stratus. They are often surrounded by a hazy, structureless nebulosity without definite boundary.

They sometimes appear and disappear within a few hours, but it would seem that they also sometimes remain in nearly the same position for several days. Probably they are of the same order of permanency as the spots and faculæ.

The instrument employed in these observations was the same 5 prism spectroscope described in previous numbers of this *Journal*.

The forms of the prominences have been studied by opening the slit some 20'' or 25''. Only the smaller ones can thus be seen in their whole extent at once. The larger ones generally have to be worked out piecemeal, though occasionally one is bright enough to allow the entire opening of the slit. This was the case with No. 4 of Oct. 7th.

The dimensions are estimated, the basis of estimation being the known angular length of the slit 3' 18'', determined by noting the time required for the sun's limb to pass across it. Some little irregularities upon the jaws of the slit, which give rise to lines running longitudinally through the spectrum, greatly aid the judgment, and the same is true of the intervals between the spectrum lines

near C, (through which all the observations have been made). I think the estimates reliable within 5'' as a general rule. The scale of the sketches is about $\frac{1}{100}$ of an inch to a second of arc, which represents very nearly their apparent size, referred to the limit of distinct vision, and corresponds to a magnifying power of 206. The position-angles are determined by a graduated screen on the piece which carries the collimator slit, and are correct within 2° or 3°, unless near 0° or 180°, or in windy weather, when the probable error might be from two to three times as great.

Hanover, N. H., Nov. 6th, 1869.

NOTE.—Having just received the volume of the *Comptes Rendus* of the French Academy of Sciences for the first half of the current year, I find that I have been anticipated by M. Faye, in respect to the method of observing the contact of an opaque body with the disc of the sun by means of the spectroscope.

At the Session of Monday, January 11th, 1869, he proposed essentially the same use of the instrument in a discussion upon the observation of the transit of Venus.

Hanover, Nov. 16th, 1869.

Explanation of Plate.

Figs. 1, 2, 3 and 4 represent the different forms assumed by a very brilliant protuberance observed Oct. 7th—position-angle 125°. The first was taken at 2.20 P. M., the second at 2.35, the third at 2.55, and the fourth at 3.30.

Figs. 5 and 6 are drawings of a large prominence observed Oct. 7th and 8th—position-angle 70° to 80°. Fig. 5 corresponds to 2.45 P. M. of the 7th; Fig. 6 to 3.30 P. M. of the 8th.

Figs 7 and 8 represent a small but active little prominence observed Oct. 8th—position angle 255°. Fig. 7 gives its appearance at 2.30; Fig. 8 at 4 P. M.

Fig. 9 represents a small but very bright goblet-shaped prominence observed Oct. 7th—position angle 355°; time 1.50 P. M.

Fig. 10 represents a small prominence observed Sept. 28th—position-angle 172°; time 5.10 P. M.

Fig. 11. The upper portion represents a doubling of the bright C line observed in the spectrum of the prominence delineated in Figs. 7 and 8. The precise point of the prominence which produced the doubling was the upper right hand corner in Fig. 7.

The lower portions of the same figure represents an appearance observed in the dark line C, on the body of the sun, Oct. 7th, 1.40 P. M., at a point 35'' from the sun's limb—position-angle 266°

Fig 7.

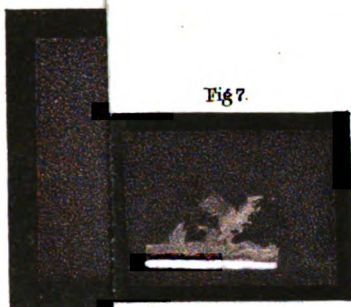


Fig 8.



Fig 9.

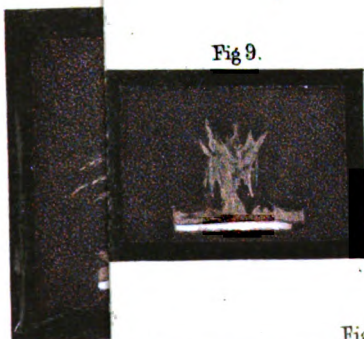
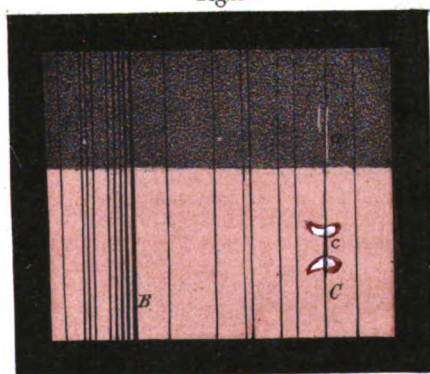


Fig 10.



Fig 11.



THE FESTINIOG RAILWAY.

THE little Festiniog Railway, of 2 feet gauge, presents a striking example of commercial success, and did its yearly accounts come before the general public they might, perhaps, create a feeling of astonishment. The original capital of the company was 36,000*l.* applied to a line of 13 miles, but, their borrowing powers being exhausted, they have since almost reconstructed their line, erected workshops, manufactured their rolling stock, &c., wholly out of revenue, until the whole expenditure now stands at about 86,000*l.*, the company having this year obtained powers to capitalize the revenue thus applied.

In the year ending June 30th, 1868, the train mileage was 46,732 miles, averaging six trains each way daily for the 313 working days of the year, or, say, 1,878 down trains loaded with slates. The weight of slates taken into Portmadoc was 112,052 tons, equal to nearly 60 tons per train, while 14,693 tons of merchandise were carried on the return trips, besides passengers, both ways, paying 3,381*l.* The slate trucks, of course, return empty from Portmadoc to the quarries, the earnings from slate traffic being wholly derived from the down trains, although, by the usual railway fiction, the trains which really run all the way down hill, are, we believe, called "up trains." The carriage of slates returned 15,798*l.* 18*s.* 7*d.*, equal to nearly 2*s.* 10*d.* per ton carried, for the 13 miles down, or 2*d.* per ton per mile, and 13*s.* 6½*d.* per down train per mile. The total receipts were 22,852*l.* 13*s.* 5*d.*, or 9*s.* 9½*d.* per train mile in both directions. The working expenses were 9,700*l.*, or, say, 42 per cent. of the earnings; but of this sum 1,223*l.* were royalties paid under the name of "tonnages," 779*l.* were parish rates, 382*l.* passenger duty and income tax, 1,481*l.* for station masters and staff, &c.; the charge to locomotive department being 700*l.* only. The actual locomotive expenses are very moderate, notwithstanding that with driving-wheels but 2 feet in diameter, and with coal at 15*s.* per ton, the cost of fuel is necessarily rather high. Thus it will be seen that the net profits of this little railway have amounted to more than 30 per cent. of the original capital, and to upwards of 12½ per cent. on the total outlay on the undertaking, the larger portion of which has been paid out of revenue.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, November 10th, 1869

The meeting was called to order with the Vice-President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the Minutes of the Board of Managers and reported the donations received at the stated meeting held November 10th inst.:—From the Royal Astronomical Society, the Zoological Society, the Statistical Society, and Francis Cranmer Penrose, Esq., London; The Literary and Philosophical Society and the Association for Preventing the Explosion of Steam Boilers, Manchester, England; l'Academie des Science, l'Impereal Ecole des Mines, et la Société d'encouragement l'Industrie Nationale, Paris, France; the Natural History Society, Montreal, and the Literary and Historical Society, Quebec, Canada; Hon. Hamilton Fish, Secretary of State, Prof. J. H. C. Coffin, Superintendant of the American Ephemeris and Nautical Almanac, the Smithsonian Institution and Frederick Emmerick, Esq., Washington, D. C.

The Actuary further reported that Mr. James S. Whitney had resigned his membership in the Board of Managers.

The various Standing Committes reported their minutes. The Resident Secretary read his report on Novelties in Science and the Mechanic Arts, after which the meeting, on motion, adjourned.

HENRY MORTON, *Secretary.*

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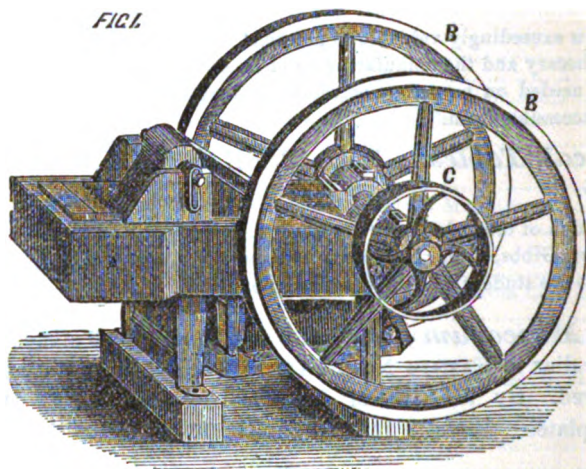
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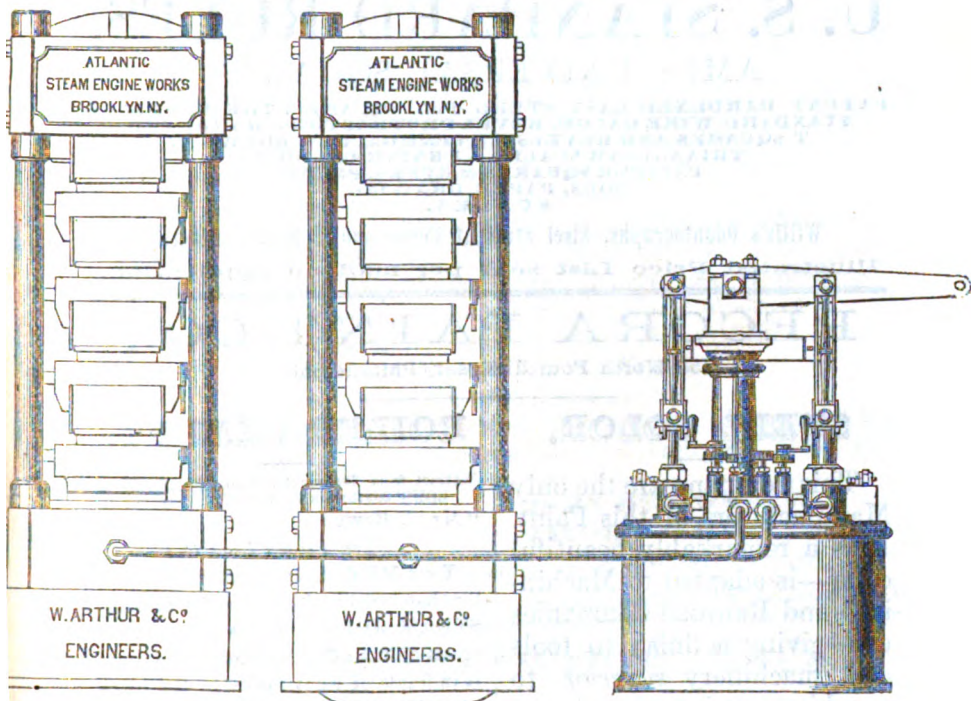
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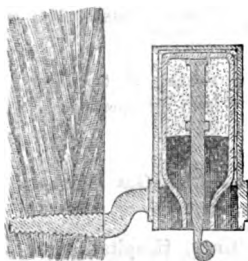
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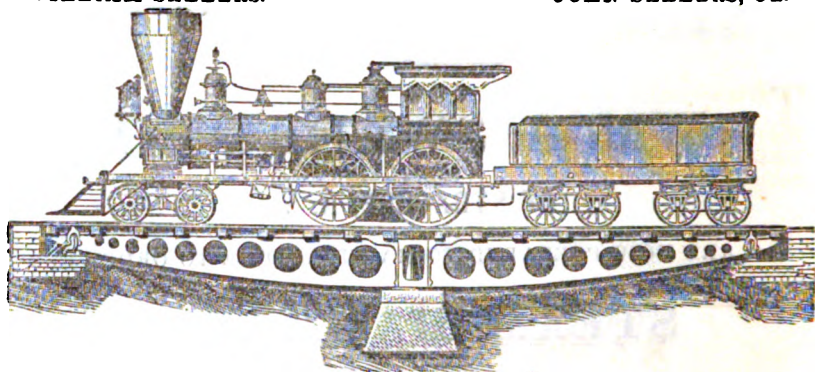
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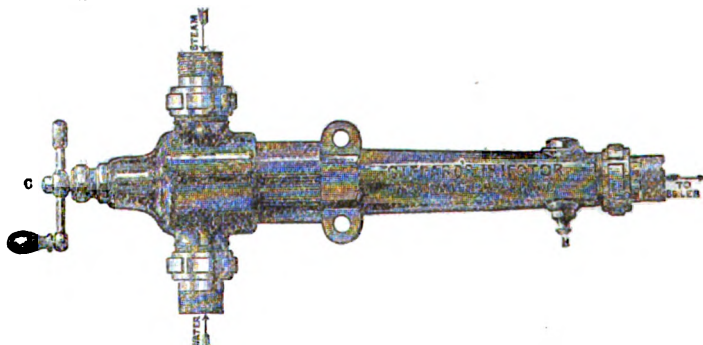
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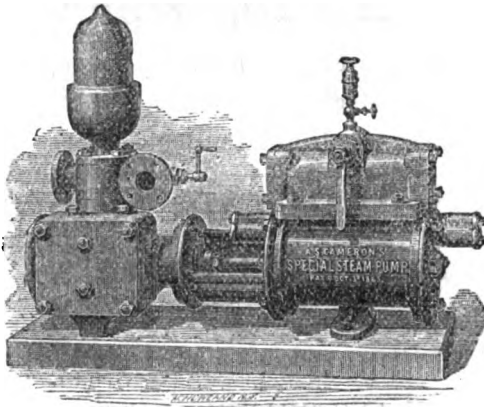
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SIR,—We have had your "Ejector Condenser" in operation for nearly three months, and are satisfied with its working.

Having tested the consumpt of fuel, both before and after it was applied, we find the saving to be *fully twenty-seven per cent.*

I am, Sir, Yours truly,
(Signed) JOHN NEILSON.

Alexander Morton, Esq.,
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GLENGARNOCK WORKS,
DALEY, Ayrshire, 28th September, 1869.

DEAR SIR,—Your "Ejector Condenser" has been working at Ryesholm Pumping Pit since 9th May last; it gives twelve pounds vacuum, and *saves above twenty-seven per cent. of fuel*, and has never been the least out of order during that time. We are highly satisfied with its working.

Yours truly,
(Signed) ARCHD. GRAY.

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The first of Morton's "Ejector Condensers" was fitted upon Craigston Pumping Engine, Lugar, and has now been in constant use for twenty months, during which period we have not required to expend one penny in up-keeping or repairs.

The Condenser and Throat are at this date as free from deposit or sediment, and as in good condition as when first fitted up.

We are unable to state definitely the saving in fuel effected, as two other engines, performing varying amounts of work, are connected with the Pumping Engine to the same range of boilers.

We are now so well satisfied (after such a lengthened trial) with the results, that we have ordered additional "Ejector Condensers" from Mr. Morton.

For EGLINTON IRON CO.,
(Signed) R. ANGUS, Manager.

Alexander Morton, Esq.,
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COATBRIDGE, 4th October, 1869.

DEAR SIR,—We have applied one of your "Ejector Condensers" to an old high-pressure engine which was too light for its work, and also short of boiler power. The Condenser has now been working for the last three months, and gives no trouble to the attendant (a common laborer); lifts the water 11 feet, giving an average vacuum of 23 inches. The saving in fuel is *about twenty-five per cent.*, the engine and boiler being now equal to their work.

Yours truly,
(Signed) STRATHERN, MURRAY & PATERSON.

Alexander Morton, Esq.,
87 West Nile Street, Glasgow.

PONTIFICAL MARINE,
CIVITA VECCHIA, March, 1869.

This is to certify that Morton's Patent Condenser was applied to the twin screw steamer "Flora," built by Messrs. Seath & Co., ship-builders, Clyde, and the appliance of the same was a complete success. Having been present at the trial, I had the gratification of witnessing the working of the same, and have no hesitation in saying that as a Condenser it stands unrivalled.

(Signed) GEO. THOS. INGLE, Chief Engineer.

Alexander Morton, Esq.,
87 West Nile Street, Glasgow.

GLASGOW, 26th March, 1869.

DEAR SIR,—We have great pleasure in testifying to the satisfactory trial of your patent Condenser on board of the twin screw steamer "Flora," although this being the first fitted on board of a steam vessel. We consider the trial highly satisfactory in every respect, and shall not fail to recommend it in all cases coming under our notice. We are, Dear Sir,

(Signed) T. B. SEATH & CO.

THE EJECTOR CONDENSER.

MORTON'S PATENT.

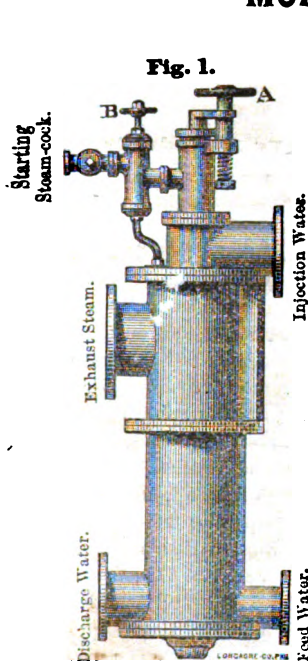


Fig. 1 is for Engines with one Cylinder.

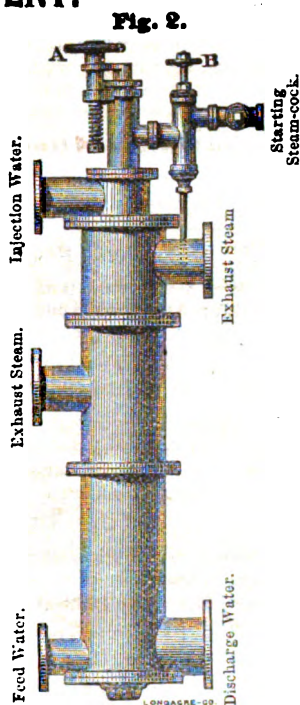


Fig. 2 is for Engines with two Cylinders.

This Ejector Condenser is applicable to all steam engines and to the vacuum pans of sugar refiners, when sufficient water for condensation can be obtained. It dispenses with the air-pump, saves all the power required for working that pump, occupies much less space than the ordinary jet condenser and air-pump, and has no parts constantly in motion, thus obviating the necessity of skilled attention and frequent repairs: it can be placed on any part of the exhaust steam pipe.

It can be applied to many of the existing non-condensing steamboat engines; it will, with their present consumption of fuel, give about a tenth more speed, or, at the same rate of speed, it will save from 20 to 30 per cent of their fuel with considerably less boiler pressure.

For a description of the apparatus, with reports on its efficiency and theory of its action, see the *Journal of the Franklin Institute*, of Philadelphia, for November and December, 1869.

Reference is also requested to the accompanying testimonials, as to the merits of the apparatus.

The Patentees have placed the sale of the American patent in the hands of the undersigned, to whom application is to be made.

DENNISTOUN & CO.,
No. 22 Exchange Place, New York.

Contents for December, 1869.

Illustrations—One Plate and Twelve Woodcuts.

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